

STRAIGHT

Modern Methods of
Brick and Tile Manufacture

Mechanical Engineering

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MODERN METHODS OF BRICK AND TILE MANUFACTURE

BY

Halver Rufus Straight

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
OF THE
UNIVERSITY OF ILLINOIS
PRESENTED JUNE, 1907

UNIVERSITY OF ILLINOIS

June 1, 1907

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

HALVER RUFUS STRAIGHT

ENTITLED MODERN METHODS OF BRICK AND TILE MANUFACTURE

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

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MODERN METHODS OF BRICK AND TILE MANUFACTURE.

I. INTRODUCTION.

The scope of this paper has been limited to the manufacture of brick and drain tile from clay. The sand-lime, and cement brick and tile industry is in no way related to the manufacture of wares from clay, and therefore could not be discussed without making this paper too long for the time possible to spend upon it.

The purpose of the writer has been to take up in detail, and describe all methods used in the manufacture of the courser clay wares with due regard to the clays used, and methods used in their reduction to a plastic state of suitable fineness of grain. Machines used in all these processes are described with cuts and sketches in such a manner that a person not versed in the mechanisms of the machines could easily understand their workings. The drying and burning are taken up under their respective headings and treated in as thorough a manner as was possible without going into minute details of construction.

CLAYS SUITABLE FOR THE BRICK AND TILE INDUSTRY.

The clays suitable for manufacture into brick or tile consist of two distinct varieties,- 1. The secondary clays of which the main portion of the clays of the earth's crust is composed are of two kinds. Of these the commonest, and generally the least valuable for the clay industry, is that of glacial origin. These clays are the debris of mountains mixed, and

ground by glaciers into a more or less even mixture of quantities of aluminates and silicates with widely varying quantities of other minerals in small percentages. After these clays finally were left in their present resting place, the process of mixing was carried yet farther by the earth water dissolving some of the constituents, and depositing them in another portion of the bed lower down probably in the hydrated form. As time went on the pressure, and possibly the heat present, caused many of the hydrates and the carbonates present to change into some other more stable form with a possible change of color. Some glacial clays have been sorted out by the action of streams and with but very little change, have been deposited again. Such clays are called alluvial clays, and are generally valuable to the clayworker. Pebbles of the different primary rocks, which being less easily disintegrated than those surrounding them, have remained intact, and have been worn more or less smooth by the reducing action of the glaciers. These harder pebbles are from the bed of mother rock from which the clays were reduced, and are almost entirely of igneous origin.

We find in the sedimentary clays the other kind of secondary clays by which is meant the water washed as well as the wind blown, or, as the latter may be called, the loess clays. In these clays the mixture is generally very even with the possible exception of particles of coal which was sometimes deposited in their layers in the clay bed. The sedimentary clays are generally called shale or fire clay, and are nearly always found in close proximity to coal beds. Very few peb-

bles are found in such clays because in the case of the water washed clays the substance was carried in the water as silt, and the pebbles such as were carried at first by a high velocity of the water were dropped long before the velocity of the water became low enough to deposit its load of silt. Due to this manner of formation shales are generally found to have a very fine and even grain. Under the head of sedimentary clays, shales proper are not the only formations to be found, but fire clays also come under this heading. The disintegration of pure feldspar into a kaolin is often accompanied by a washing away of the kaolin as was the glacial clay in the formation of shale beds. The deposits thus formed are highly refractory, and are called fire clays. These clays are not found in a state which is easily reduced to the plastic in this country, but are found already plastic in Germany and France. Soaking and aging is used in this country to reduce these fire clays to a plastic state.

2. The primary clays are too valuable to be used in the manufacture of common bricks or tile for one reason, and the other, and, perhaps, better one is, that the product would not be as tough after burning. Primary clay beds also contain a large amount of sand, and have to be washed into a slum before they can be used. This operation is expensive, and must be carried on with great care. Only a very few deposits of such clays are to be found in this country.

II. REDUCTION.

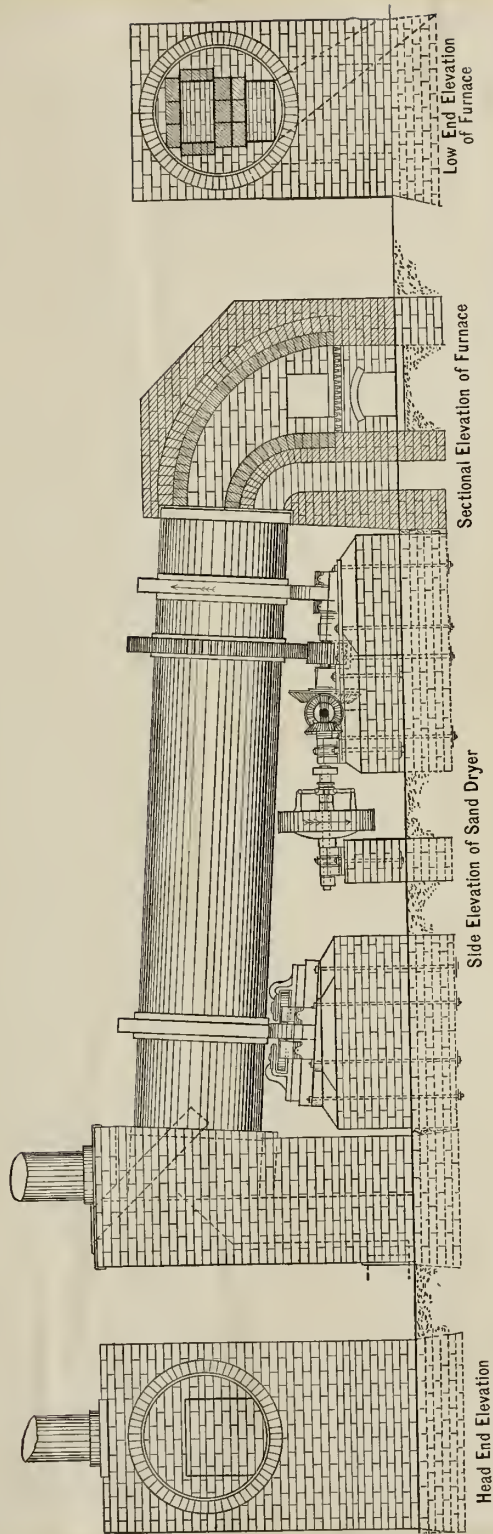
The question of reduction is all important in the clayworking industry for, upon it in a great measure, the evenness of color and grain in the finished product depends, and a wide variation of color, or a lumpy ware, is not to be desired under any circumstances. In treating this subject it was believed best to follow the clay through the different processes from the raw state to the prepared material ready for moulding. The three general methods will now be taken up in order as to presentage of water contained in the clay necessary to fit it for that process.

DRY PRESS PROCESS.

1. In the dry press process of moulding the material used is generally a shale, or fine alluvial or loess. The reason for this selection is because of the even color and density desired in all dry press products, and shales and such fine grained clays are the only common clays upon which the manufactureer can rely for a certain color at a certain temperature. Since the shales are of a hard and tough nature, the dry-pan is the machine most generally used in the initial reduction. In the other two clays the bar disintegrator does the best and fastest work. A few of the shales come out of the bank in such large masses that a jaw crusher is interposed between the dump and dry-pan with a saving of total power used, and wear-and-tear on the dry-pan. The saving of strain upon the dry-pan is from the fact that when large pieces enter

the dry-pan the mullers mount the large pieces, and upon either crushing them or rolling over them, submit the frame of the machine to quite large shocks which, although it is designed to withstand them, is hard upon its parts. Where jaw crushers are used the largest pieces to enter the pan are not over 1 inch in their greatest dimension. The capacity of the dry-pan with such an auxiliary crusher is increased from one-quarter to one-half more than its capacity when doing the work unaided. We have a good example of such an arrangement at the works of the Postum Brick Company's works at Crawfordsville, Indiana.

From the drypan the dust and small grains are carried up by cup elevators, and run over a screen. The tailings are returned to the pan for further reduction, while the finer material which passes through is then run into a storage bin, or directly into the mixer from which it goes into the machine. The purpose of the mixer is to produce a homogeneous mixture so that no variation in color of the product will result. In the fine alluvial clays the screen is sometimes omitted where the content of stone and other foreign matter is small. The clay for this process should contain from 3% to 6% of water depending upon the nature of the clay. Clays directly from the bank containing more than this amount are dried in rotary driers (Fig. 1) very similar in construction to the kilns in which cement cinder is burned. There are also clays which do not contain enough water to form a bond. The best method of adding water to these has been by the use of steam which is made to penetrate the mass in a steamer, or is added just before



Direct Heat Sand or Clay Dryer.
Fig. 1.

the clay goes into the press.

STIFF MUD PROCESS.

2. This process is used in a majority of plants manufacturing a product from clay because of its adaptability to all glacial clays and most of the shales. Some shales will not become plastic without long weathering which is expensive and hard to carry out. In this process, the clay may be reduced to a fine grain by either of the methods used in the dry press process. After a rather fine dust is obtained, the material is brought to a plastic state by running it through a pugmill. This is generally only necessary with the hard shales, and such clay which contain limestone pebbles, which are taken out by the dry-pan and screen or bar disintegrator and screen. There are cases where the limestone is not in large enough quantities to prevent a fine grinding and mixing of the whole without weakening the ware. In case these pebbles are not removed or ground, the finished product is most apt to be injured by the burnt lime slacking, and forming unsightly and injurious blotches on the surface.

The pebbles which are removed by aid of the dry-pan are not crushed at all, but the mullers are set at a distance of one-half to three-quarters of an inch from the plates so the clay and pebbles are simply separated. Since the pebbles are not crushed, they will not go through the screen plates of the pan, and, therefore, rolled until it becomes necessary to "run the pan dry", and remove the pebbles by the use of a shovel

or especially constructed dumper. Another common method of removing the larger pebbles is by the use of conical rolls which are set so that the pebbles are rolled toward the small ends and out. In this machine, the rolls must be set fine enough so as to crush all pebbles which are not rolled out. Other methods of causing the pebbles to roll out are in use. Among them are the spiral and corrugated surfaces on rolls. The capacity of a set of rolls is limited to about 95,000 standard bricks per day of ten hours because the speed at which they may be run and the length of the rolls themselves is limited by working conditions. Another method of removing the pebbles, which is used in many cases where the clay is of a rather loose nature, is by means of the bar disintegrator, which pulverizes the dry clay, and cleans the gravel, which is separated out by a screen. Cases have come under the writers observation where the pebbles, not being entirely free after running over the screen, were run through a slummer, and the slum used in the pugmill for mixing. Pebbles thus washed are free enough from clay to be used in concrete and other masonry. The cost of slumming may be more than paid for in this way. In some cases, the slummer receives all the clay directly from the pit, and, after washing, allows the slum to run off into settling tanks where it is settled, and dried into a stiff mud. This latter process is used a great deal in the pottery industry, and in all finer wares. Its application to the courser ware manufacture is limited because of the high cost of carrying out the process.

A machine recently invented for removing pebbles from clay consists of a smooth steel disk, the plane of revolution of which is at a right angle to the axis of a column of clay, which is forced out by an auger as in a tile machine. The disk is revolved at a high velocity, and the column of clay is carried downward in small rolls. A sharp knife set close to the surface of the disk sorts out the pebbles, and guides them off into the waste heap. The distance at which the knife is set from the surface varies with the size of the most common of the small stones occurring in the clay.

The method of blowing out the clay grains from among the pebbles has been tried, and can be made to work successfully, but this method requires power to run the fan, and is no better than the screen.

In some cases the clay is entirely or comparatively free from small pebbles, and the roll crushers are best used. When these are used the clay need not be dry, and in fact, works better if it has about 10% of moisture. The roll crushers or disintegrators, as they are called, if run at high velocities, are apparently the most practical, and cheapest machines that can be used for all medium soft clay and shales. The wet pan is used in the manufacture of sewer pipe and fire clay ware because of the more thorough mixing the plastic material may receive. In England the clay is generally quite free from pebbles, and the wet pan is used in series with a number of sets of rolls. The tendency of the English seems to roll the clay to a uniform plasticity, rather than pug it with the common

mill, as is the practice in this country. A wet pan requires, however, more power to operate than a pair of rolls, and besides requires constant attention. The rolls need receive very little attention at any time. These considerations together with the heavy weight of the wet pans, thus requiring a heavy foundation, if set above the mill as the English do, or an extra elevator if set at the ground level as is the common practice in the United States, all tend to lead manufacturers, using the stiff mud process, toward the use of the rolls and pugmill.

THE SOFT MUD PROCESS.

3. The soft mud process is the poor man's process, in most cases, because of the small amount of machinery required to operate a plant. This is not always the case for sometimes large factories use this process because of the sand faced brick which are the result of this method of manufacture. The clay used is generally near the surface and of glacial origin. It must not contain any large amount of gravel, because there is no effective provision in the process for its removal. The clay is generally dumped directly into a pugmill or set of rolls, and generally all the pugging it receives is in a small pugmill in which it may receive some water, and is thus reduced to a putty like consistency. Often a granulator is used on the clay before it passes the rolls, which gives a more even feed, and increases the capacity of the rolls. The granulator in this same capacity is used more often to produce an even feed to the rolls, than for the reduction it effects.

III. MOULDING.

1. DRY PRESS PROCESS.

In this process the material being reduced as described before to a fine dry meal or powder, with generally not over 6% mechanical water, is run from the bins, or mixer above the moulding press, into the pockets or dies. Each time the press makes a downward stroke, a certain amount of clay which of course varies in different plants for different clays and different sizes of brick is admitted into the pocket. The press as described in the chapter on machines now presses the meal so that the little moisture which is in the clay is enough to form a bond. The great pressure necessary to do this amounts to about 5,000 pounds to the square inch of surface on the brick is secured by means of toggle joints, cams, or ex-centrics. It is quite necessary that the pressure should remain on for some time, (approximately one and one-half seconds) because a dry clay is viscus when being pressed, and will not yield to make the desired density on the corners and edges. If the density is not great enough on the corners the brick crumbles easily. Such machines require very heavy construction and foundations.

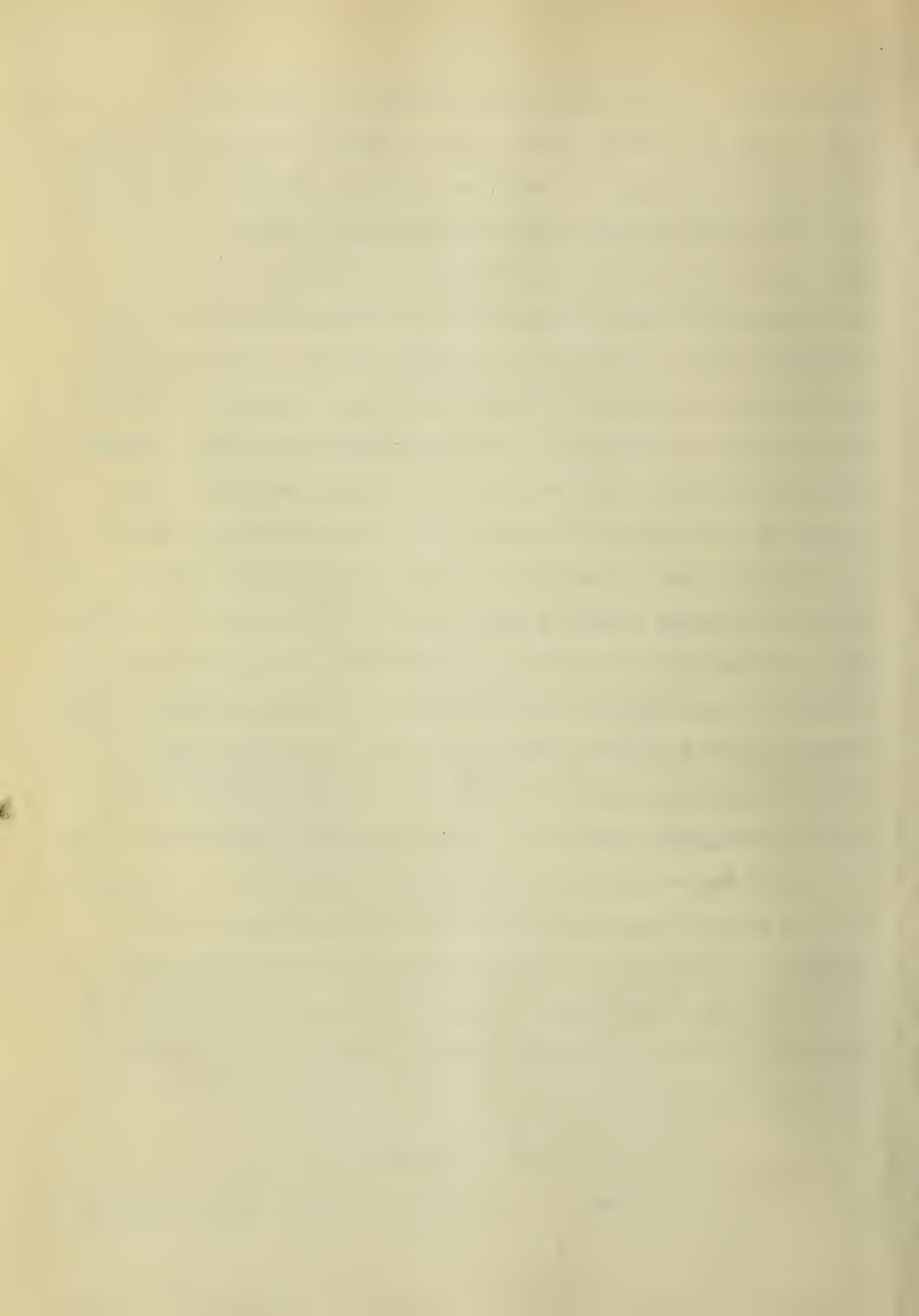
2. STIFF MUD PROCESS.

The machines used in this process are almost universally of the auger and pugger type. The exception is the sewer

pipe press. In the first above named the clay enters the puggers and is worked forward to the augers, which are generally shaped after the frustrum of a cone, so that the velocity of the clay in the augers is constantly increasing as it nears the small end at which it enters the die. The die shapes the clay which is constantly forced through by the pressure exerted on the clay behind by the augers. In some machines the puggers are horizontal such as in the Fate, American, Madden and Chambers while in such machines as the Brewer and Success the puggers operate in a vertical position. The machines of the first class are not adapted to clays which are inclined to become slippery or soapy upon being reduced to the plastic state. The first class are, however, much used for the moulding of shales but are generally equipped with some kind of a force feed. There are two types of these feeders. The most common is composed of two revolving shafts set from 15" to 24" apart, upon which long knives set staggered, so that the two when revolving always over and inward force the clay down. The second is made up of one or more plungers actuated by excentrics. In moulding tile a core is held inside the die so that piece which is formed is hollow. The core is held by a rod running back into the machine. It is often necessary to lubricate the die to prevent the curling of corners. This is done by using steam or oil under pressure.

3. SOFT MUD PROCESS.

This process of moulding is carried out by means of



mould boxes in place of dies. The boxes are filled by a regulated amount of clay admitted from above through a chute. The clay is then pressed by a plunger actuated by means of an eccentric upon the pugger shaft, or a separate shaft set above. A glance at the cross-section sketch shown in the chapter on machines will clear up mechanical details. The mould used generally are in combinations of four to six to the box and are made so that the bottoms may be removed for cleaning. The brick are moulded upon their side thus giving a more even and homogeneous structure and better corners. It is necessary to sand these moulds each time a filling is made to prevent sticking, and roughing of the corners in removing from the boxes. The sand used should be very fine. Pure white silica or glass sand, as it is called, is the best for this purpose. Ashes carried into the kiln by the gases are often used, and answer the purpose very well because of their ability to absorb moisture, but are not so good in burning because the brick have a greater tendency to stick together. The general type of machine, which does the sanding is described, in the chapter on machines. The brick are removed from the mould by turning the mould over, and giving them a certain shake which is mastered only after many trials and spoiled brick.

IV. CUTTING STIFF MUD WARES.

There are two ways of cutting the column of clay from the stiff mud moulding machines in use at present.

1. The piano wire stretched tautly between two arms or knobs is caused to cut the clay by automatic or hand mechanisms.

2. A small knife of sharp blade is revolved inside the piece and cuts the column into even lengths. This method is used only in the sewer pipe and large tile presses.

V. DRYERS.

Dryers used may be divided into three types:- 1. The natural or open air with perhaps a roof to protect the ware from the rain, 2. The semi-artificial in which the heat from the atmosphere and from some other source is used in drying, 3. The artificial dryer in which artificial heat alone is used.

1. A most primitive, but yet a very much used method of drying, is upon the level ground in the open air. This method is used particularly in the east. Around Philadelphia hundreds of acres are covered daily by brick set out to dry. It was here that sometimes a brick being rained on slightly presented a slightly roughened surface. Upon being burned, they were found to give a very fine appearance when laid up in the wall. They were named raindrop brick, and now are manufactured by means of artificial rain, because of the inability of the manufactures to secure enough by natural methods. Of course this method of drying is cheap, but often the canvas used to cover the yard is not sufficient to prevent a rainstorm washing the brick too much to be of value. The distance that the brick have to be transported to the drying floor from the machine is a very objectionable feature, yet it cannot be denied that, in some cases, this method of drying, is the most effective as well as the cheapest.

In drying the soft mud ware the greatest of care must be used in handling the brick which are over 30% water. Palates are used to carry the brick on from the machine to the dryer.



These pallets, as they rest in the dryer, are generally supported by rows of slats fastened to posts. These slats are long enough to support two or three pallets on each side of the posts, and are stacked 10 to 25 deep. The limit in breadth of stacks of pallets is the distance from the tracks upon which trucks are run. If this is too great, a workman must take too many steps, and therefore, would require too much time. The limit in height is the height to which a man can conveniently reach. Such a soft mud dryer is generally a purely natural dryer with a removeable roof of boards or canvas. A typical example of such a dryer may be seen at the works of the Stipes Brick Co. in Urbana, Illinois.

Another very common natural dryer seen where the stiff mud process is used is the slatted floor. Yellow pine slats 3" to 4" in width are placed about one inch apart upon joist elevated from the ground so as to allow a free circulation of air under, and up through the same. The ware is set directly upon the floor, generally only one tier deep, and may be dried very slowly if desired. Such a dryer is especially adapted to very large pieces such as sewer pipe, and also the most tender of clays which will not stand rapid drying.

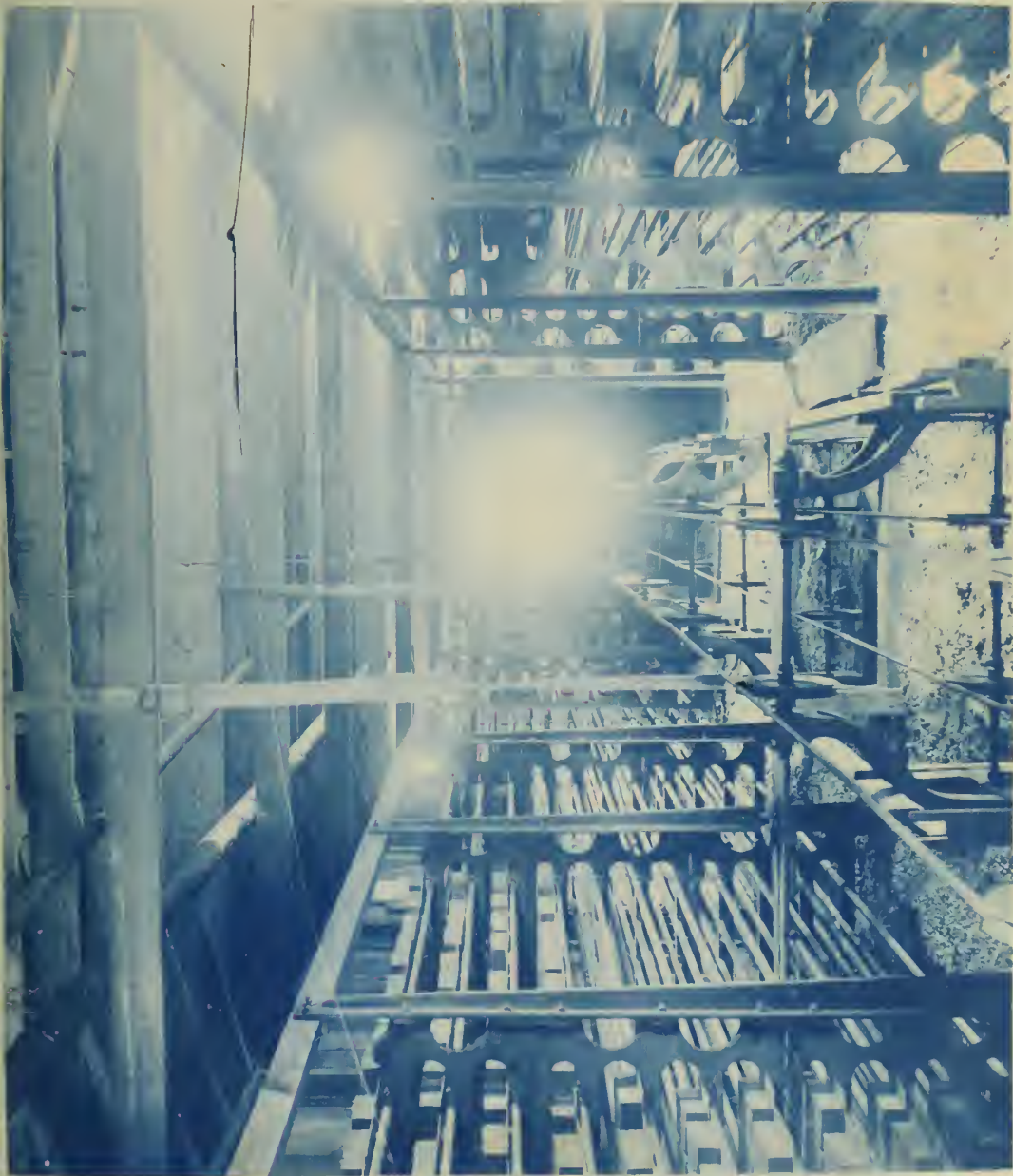
2. The semi-artificial dryer is really only a modification of the last described dryer as it is generally used in this country. It has the same general construction, but makes use of the heat from the exhaust steam in pipes under the floors, as well as the heat from the atmosphere. These dryers take the moisture out of the ware evenly and gradually,

but require close watching when the floors are first set green. Such a dryer is limited in width to about 60 to 75 feet because of the impossibility of getting the air from the side doors into the center. They are generally 2 or 3 stories in height, but may be 4 or 5. The top stories in such dryers necessarily dry slower than the lower, because of the moisture saturated condition of the air as it passes up through the last floors. The length is only limited by the distance it is convenient to truck the ware. Such dryers are best adapted to the stiff mud process.

The Martin system of drying, as taken up briefly in methods of transportation,, is of a semi-artificial nature. The tiers of 1" pipes through which the exhaust steam passes are arranged in long, and rather narrow sheds as shown in figure 1a, and 2. The pipes are supported as shown in figure 3, so that while the shed is not of fire proof construction it is practically so. The palates used are of thin steel plate upon which the bricks are taken to the dryer, and the moisture extracted. The palates being about three feet in length require the pipe rack to be about the same so that the outside air let in at the bottom does not dry the brick at all, but simply carries the moisture sweated out of the brick, up and out small stacks or ventilators as shown in figure 1. The extraction of the moisture from the brick is similar to the method of giving a Turkish bath i. e.-the moisture does not evaporate out of the faces and corners, and then bring that out of the center by capillary attraction as in open air drying, but the water is



Exterior View of Martin Dryer Fig. 1a.



Interior View of Martin Dryer Fig. 2.



Pipe Support of Martin Dryer Fig.3.

vaporized in the center and bottom of the brick by the heat coming up through the steel palates, and thus drying the whole brick out. The advantage of having the minute capillary interstices, due to the contraction as the moisture leaves, in the center instead of on the outside, as is obtained in the ordinary open air systems. ^{is obvious} This dryer is very cheaply operated, and may be used in the stiff as well as the soft mud process. Complete drying in some clays may be effected with this dryer in 6 hours time.

A German method of drying is that of placing the drying floor immediately above the continuous kiln. The ware is made by hand upon the same floors, and are let down to the kiln entrances by means of gravity elevators. The floors are slatted, and the air is let in under the lower floors through doors on the sides. The air, upon becoming heated by the radiation from the kiln, rises through the floor, and collects its load of moisture, and finds its way out through slatted ventilators on the roof. Such a dryer is a very unsanitary place for the workmen, because of their constant surroundings being moist, and being compelled to breath moist air. Such a dryer can nevertheless be run very satisfactorily, otherwise as well as cheaply.

Frequently we find clays, which will not stand rapid drying, which are loaded upon cars, and dried in sheds by the use of the combined heat of exhaust steam and the atmosphere. The exhaust steam is conducted in banks of 5 to 9 pipes of 1" diameter. The bank lies immediately under the cars and is not used except after the ware has become practically air dried.

Such dryers have the advantage of the slatted floor systems, because of a small amount of handling necessary, and comparatively small ground space required.

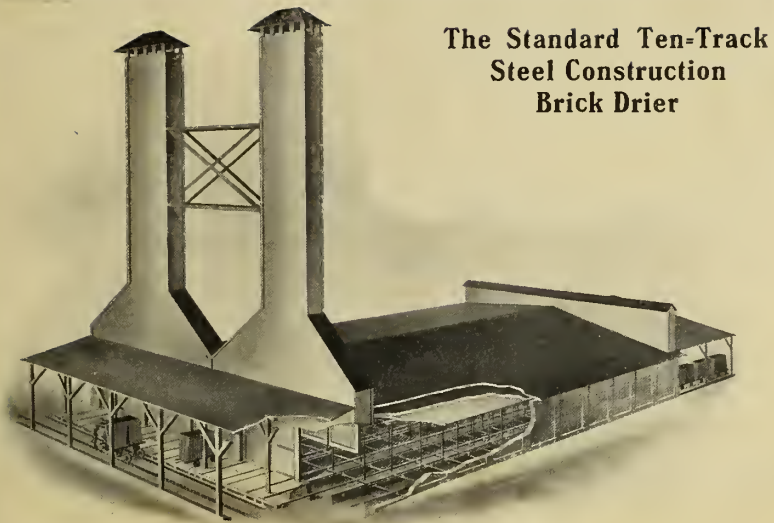
3. We come now to the artificial dryers which are by far the most used dryer on the modern brick yard. The principle reasons are because of the easy control of internal conditions which are entirely independant of outside weather conditions, and because of the rapid drying possible. These dryers were introduced into the market about 20 years ago and have made rapid strides toward simplicity, and ease of control ever since.

The Iron Clad dryer designed and constructed by the Iron Clad Dryer Co. of Chicago origionally used banks of pipes in pits below the tracks. The pipes were 8 to 10 high, and 5 to 8 wide in the banks. The tracks were originally all in one room, but in order to facilitate the addition of green ware to the dryer, the tracks have been lately partitioned off in long tunnels like compartments, which contain from 1 to 3 tracks each, and run the entire length of the dryer. A few dryers are, however, constructed upon the old principle yet because of the low cost of installation. In all of these dryers there is a compartment at the lower end of the dryer, through which air is admitted. This air, after passing up the entire length of the dryer toward the receiving end, passes up a wooden stack, which furnishes sufficient draft to keep it moving. Such stacks vary in height from 30 to 60 feet, and in cross-section from 25 to 75 square feet. Arrangements have also been made in some of the

latter plans, for drawing the heated air from the red hot burned bricks in the kilns by means of tunnels and fans, and forcing it into the dryer. This heat is thrown into the dryer through the doors, which ordinarily admitts the air.

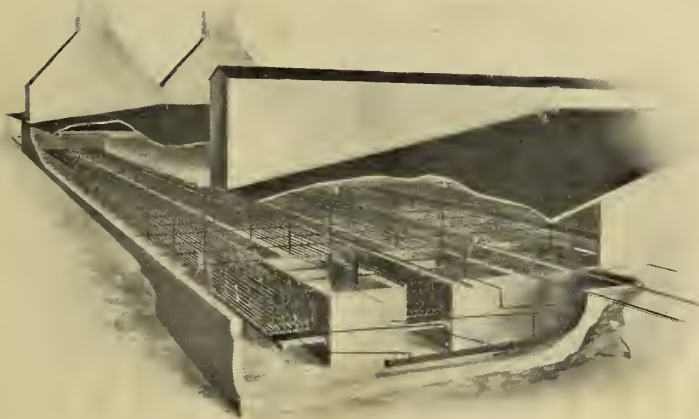
The Standard dryer was next introduced by the Standard Dryer Co. of Indianapolis, Indiana. This dryer is very similar to the Iron Clad, except that it is fire proof through out. The sides are of brick and the top of 3" concrete reinforced by steel netting, and held up by steel columns. The pipes are arranged in much the same manner, and although the company claims a few advantages over the Iron Clad they are mainly changes for the better to get around the patent features of the Iron Clad. Figures 5 and 6 show the construction of this dryer in detail. Figure 6 shows the latest arrangement of the exhaust heating system. Figure 7 shows how the pipes are set so that anyone can be lifted, and repaired, if necessary without disturbing any others.

The Bechtels Dryer constructed by Bechtels Co. of Waterloo, Ont. Canada is a combination dryer using, either the waste heat from the hot kilns, or the exhaust steam, or both. They are generally arranged to use only one method of heating. When the exhaust steam is used, it is piped to the dryer, and the heat from it, passed through coils over which the cold air is thrown by a fan. This fan throws its air into the lower end of the dryer. The air is then distributed so that it passes through only a few green bricks before it passes up one of the many small draft stacks located every few feet along



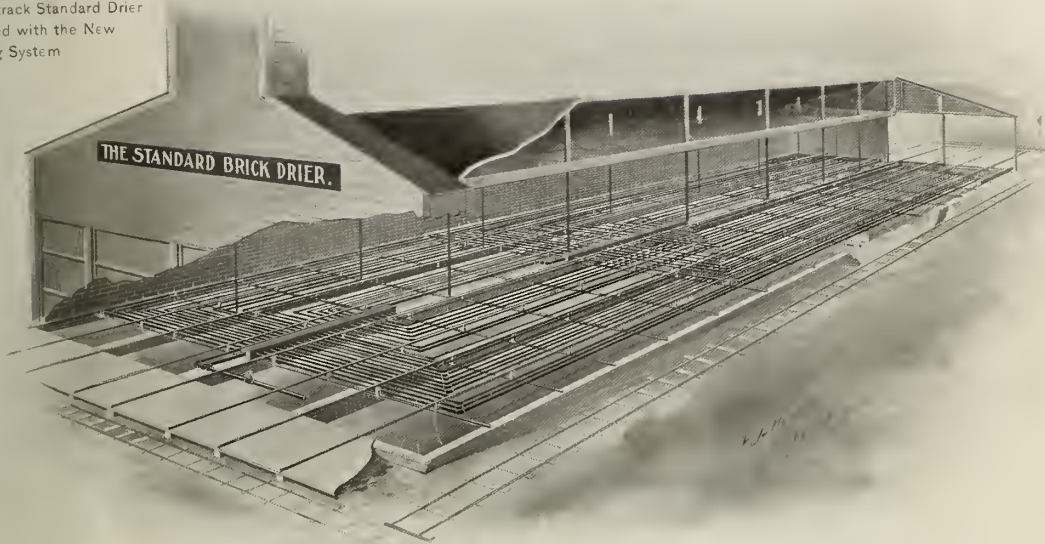
The Standard Ten-Track
Steel Construction
Brick Drier

Fig. 4



Brick Dryers.
Fig. 5.

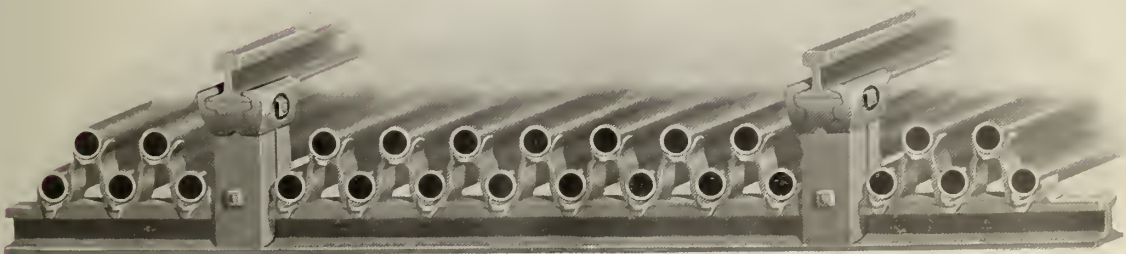
A four-track Standard Drier
equipped with the New
Heating System



3

Fig. 6.

The Standard Pipe Rack,
making every pipe acces-
sible. Rests on steel cross
ties



Details of Brick Dryers.

Fig. 7.

the building. When waste heat is used, it is taken from the kilns by means of a duct and suction fan, and thrown into the lower end of the dryer through openings up through the floor under the cars. Of course it is understood that the green ware in all such dryers enters at the end of the tunnel at which the moist air is taken out, thus decreasing the danger of checking the ware as it goes into the dryer, and at the same time drying the outgoing ware almost bone dry, because of the fact that the hottest gases are entering where the ware is being taken out.

The dryer gotten out by the New York Blower Co. is similar in design to that of the above except the ware is always on cars, while in the above it is in some few cases brought in on lift cars shown in figures 11 and 17 and left to dry. In this latter dryer the cars move the entire length of the dryer. The fan housing and various ducts are shown very clearly in figure 8, as will be noticed this dryer uses a suction fan in place of a draft chimney by which arrangement the action of the dryer is made more positive. Figure 9 shows a common arrangement for the fans and heater coils in reference to the kilns, dryers, and machine room. Notice the ducts indicated by the dotted lines in this figure.

We now come to the dryers using direct and waste heat. These have furnaces, which are directly under the lower end of the dryer into which ordinary coal is fired. The heated air and gases of combustion are lead back through a long tunnel directly under the tracks along the whole length of the dryer



Waste Heat Brick Dryer
Fig. 8.

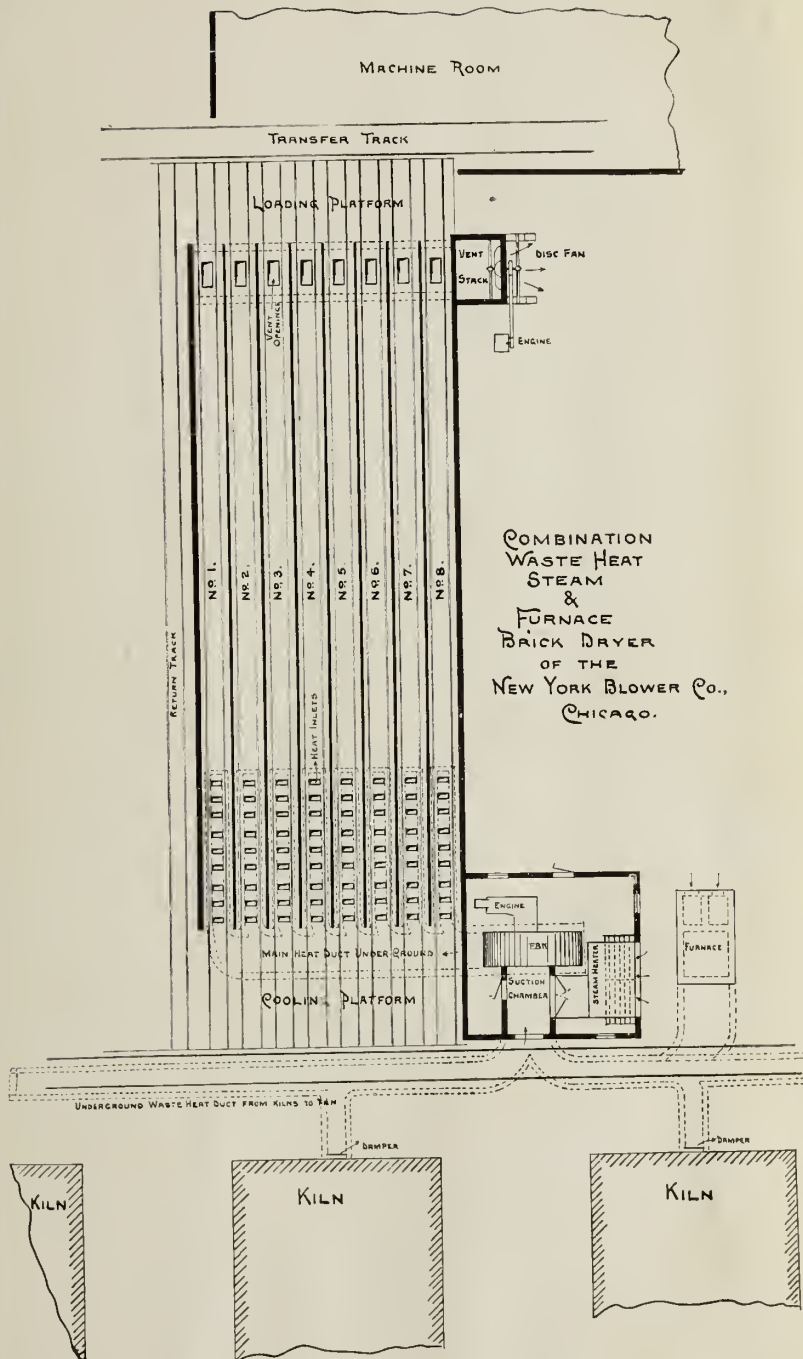
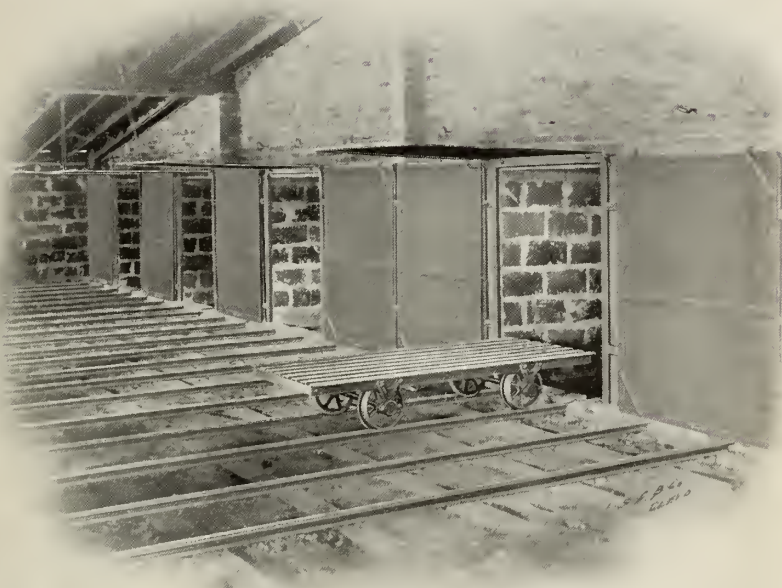


Fig.9.



RECEIVING END OF DRYER

Fig. 10.



Interior Stiff Mud Exhaust Steam Drier in yard of the Berlin Brick Co., Berlin, Ont.

Fig. 11.

(figure 12). A stack furnishes draft to all the furnaces which are arranged with one to each track. Air is admitted at the lower end of the dryer to the tunnels. This air after passing up the length of the dryer, and becoming nearly saturated with moisture, is drawn out by the furnace stack, or another similar. Where waste heat is also used, a fan is used to force the air through the dryer. These two methods of drying combined make a most excellent system which is easily controlled. Although no data upon the cost of drying has ever been gotten together it is the belief of the writer that the direct heat system when working alone is the most economical of all artificial systems. For examples see figures 13 and 14.

The J. D. Cummer Co's. direct heat dryer uses the heat from the furnaces in much the same way that the previous dryer makes use of it.

Where large tile are manufactured, the roof of the tunnels is made very thin. (Not over 3/4") Slotted floors built above the tunnels, receive the ware, and it is dried upon them by the heat of radiation from the tunnels below. The heat of radiation comes up very even, and furnishes almost an ideal means of drying large tile. Such additional floors are called decks.

A method of drying brick which might be called the first stage of burning called water-smoking is employed in the Scott system, in which the brick are run directly into the kiln from the machine on a series of delivery belts. (figure 15) The water contained in bricks as they go into the kiln may vary



DRYER PARTIALLY FINISHED SHOWING CONSTRUCTION OF FLUES

Fig. 12.



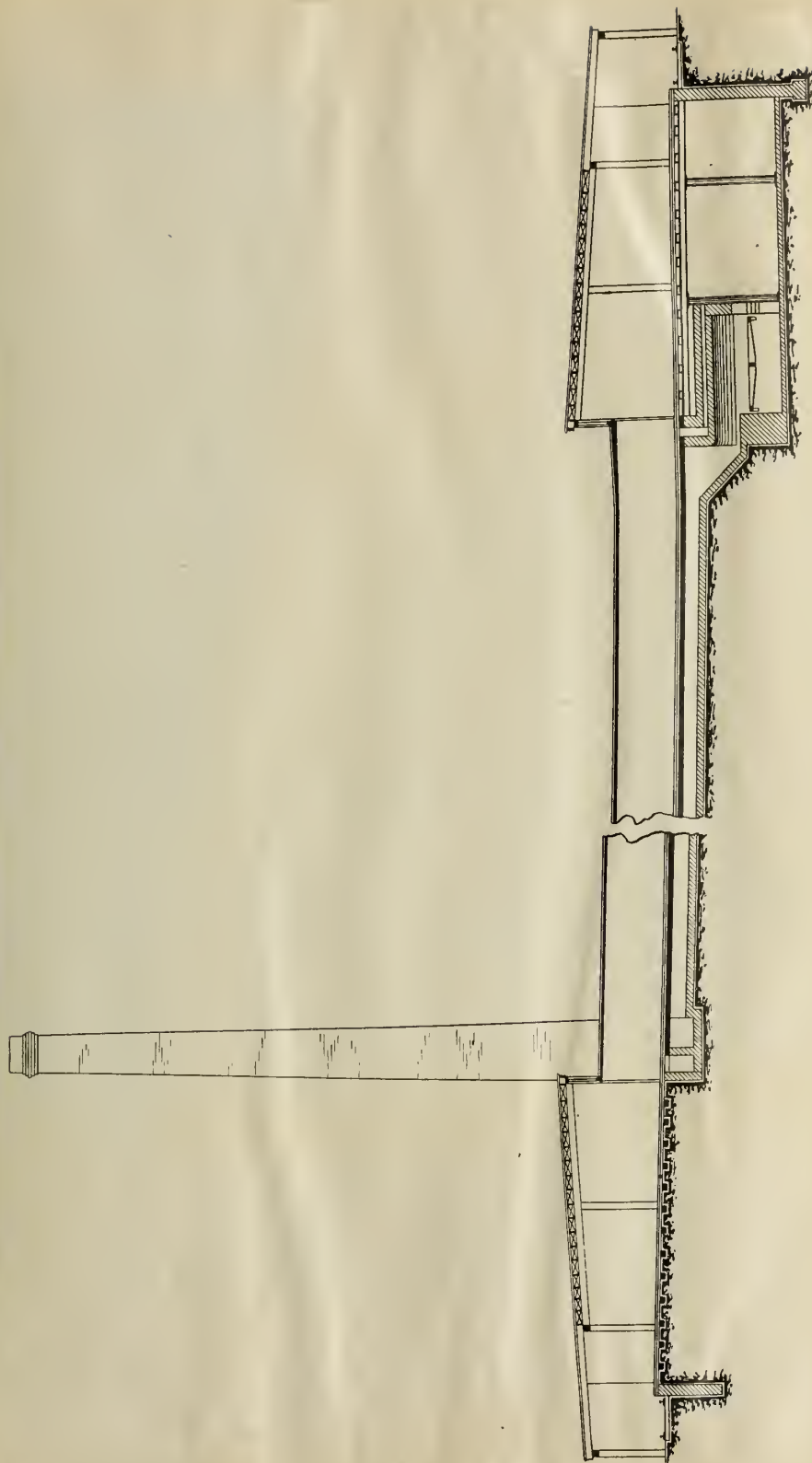


Fig. 13.

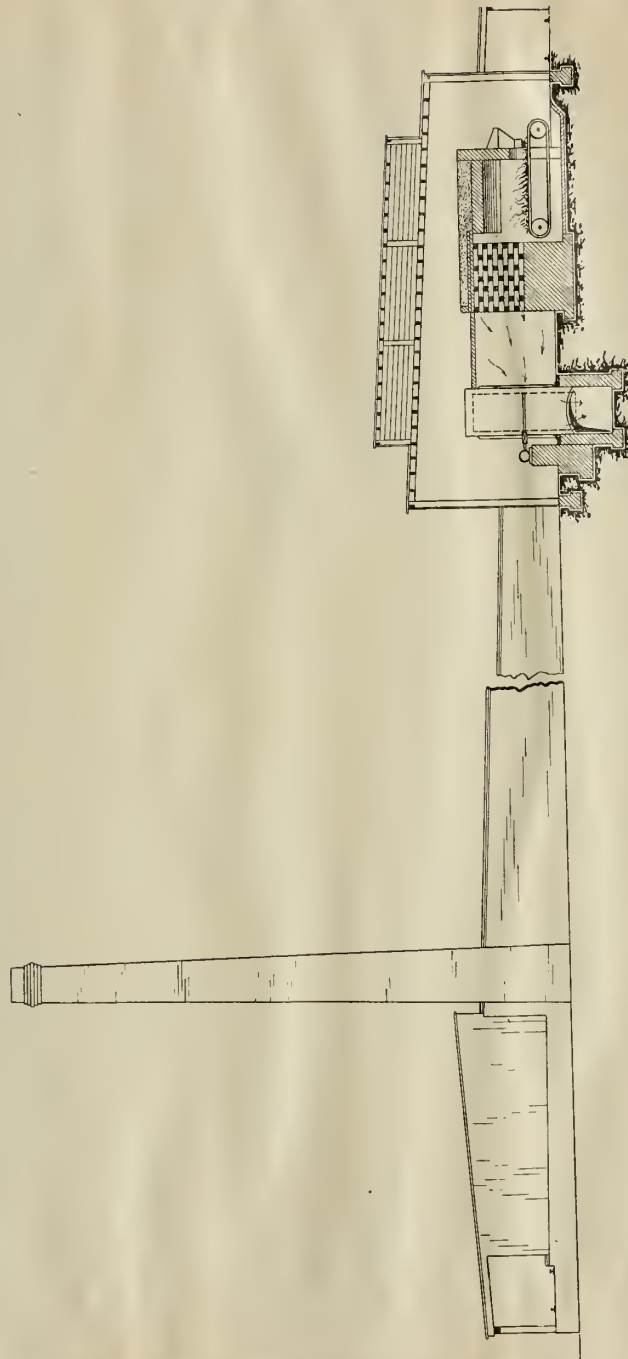


Fig. 14.



Fig. 14. The main conveyor and kiln conveyors at Scott's Plant. Photograph taken before the conveyor shed was built.

Fig. 15.

from 2% in the dry press to 23% in the stiff mud process. As the bricks are run into the kiln they are taken off the conveyor belt as shown in figure 16 and are set about 10 deep. Several chambers of the semi-continuous kiln as shown in figure 16 are thus covered all over with the brick in a day, and are dried out by the waste heat from the cooling chambers, which is forced through the drying flue shown in figure 16 and figure 151. The bricks are sufficiently dried, during the night, to stand up under another days run. The rest of the process of burning the brick is the same as in any semi-continuous kiln and will be described fully under the chapter on burning. The clay used in ware dried by this method must be porous, and dry rapidly without checking. It will be noticed that figure 151 represents an up draft kiln instead of a down draft as used in figure 16. The heat drying flues are practically the same in both, but in the up draft the moisture passes out its natural way, that is, the top while the moisture in the down draft kiln passes to the top and is carried off by a flue at the end and sides of the setting. For this reason alone the method is better adapted to the up-draft kiln.

The application of a hot floor as shown in figure 18 to dryers is in some cases necessary because of the qualities of some clays. This floor dries very evenly and slowly. In the case shown by figure 18 the lift cars are used thus eliminating the large number of cars used in some dryers, and, at the same time, giving more opportunity for drying. Figure 19 shows how this floor is sometimes used in the semi-artificial dryer with slotted floor and large side doors.

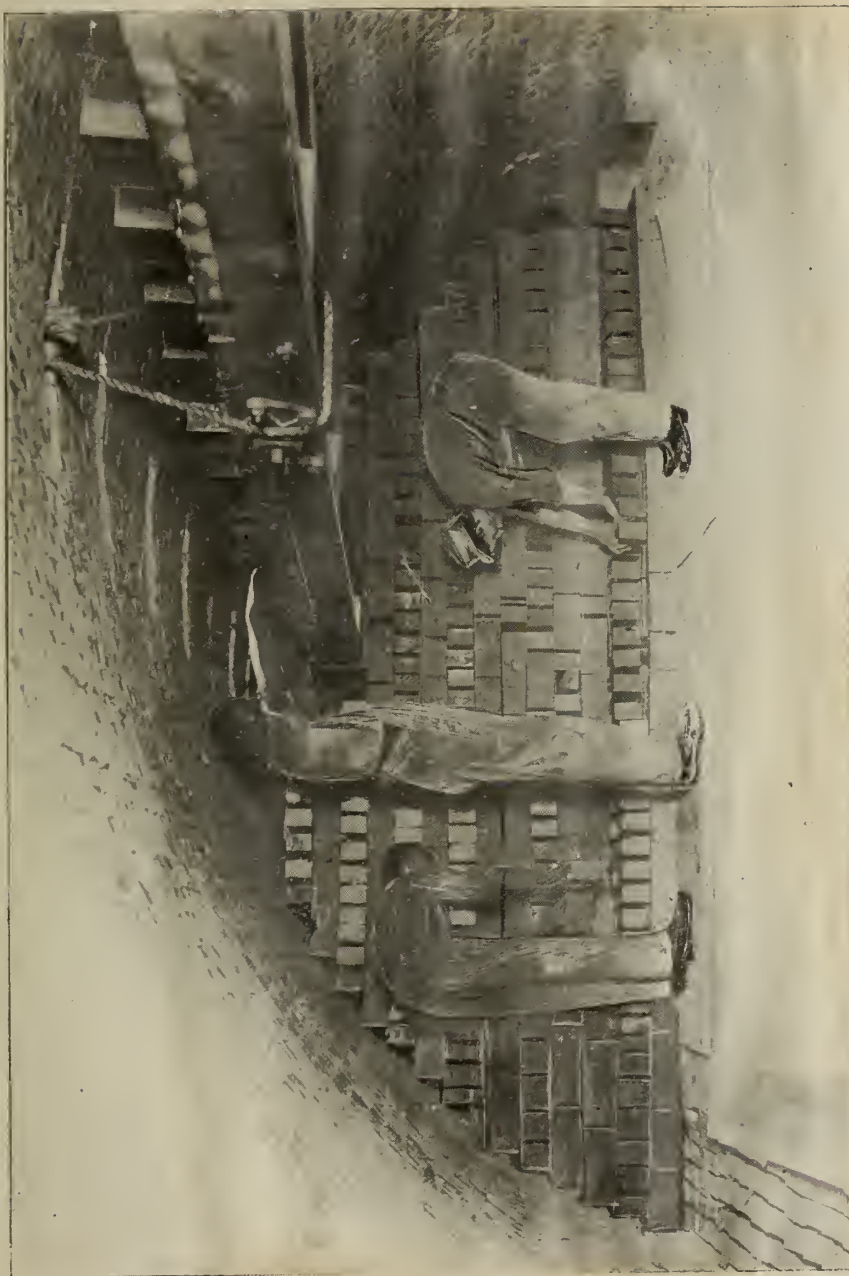


Fig. N Setting the top tier of a down-draft kiln at Scott's Plant.

Fig. 16.

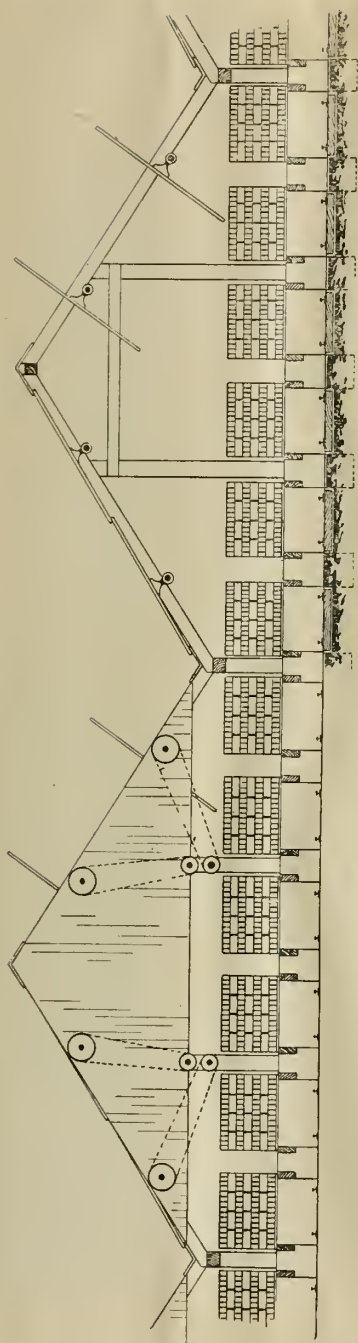


Fig. 17.

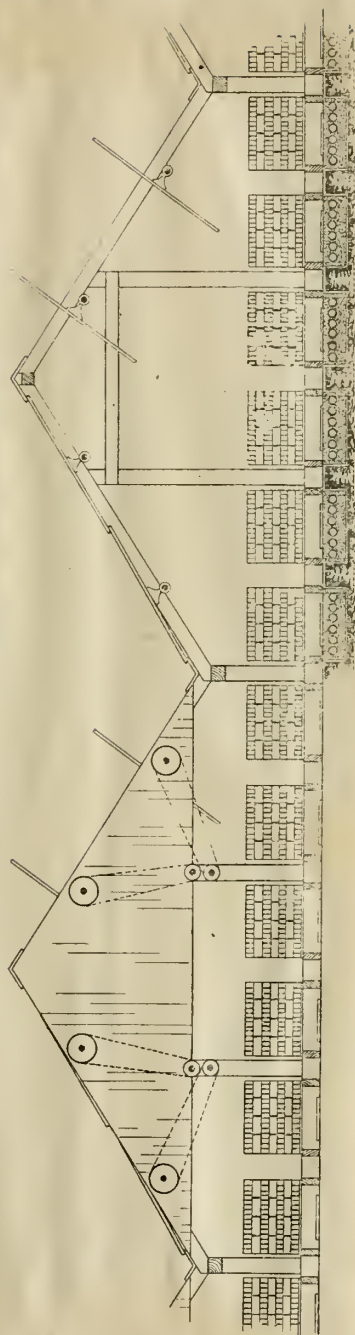
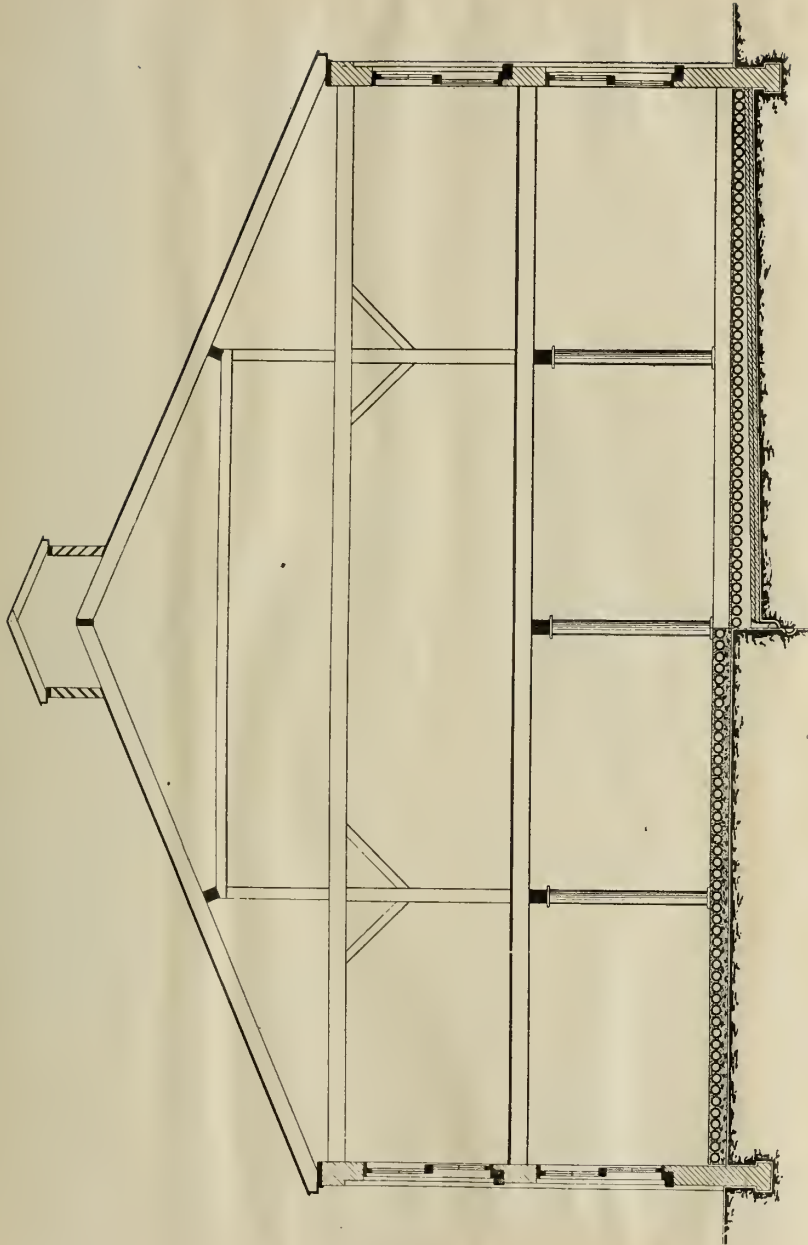


Fig. 18.

Palate Dryers,
Figs. 17+18.



Semi-Artificial Hot Floor Dryer
Fig. 19a.

VI. BURNING.

In taking up this Part of the clayworking industry, we take up that which is the most difficult, and expensive, and also the process which must be done well. A clayworker may make a rather poor product, which if burned well, will make a substantial and beautiful wall, because of the roughness of the product, but no matter how well the ware has been made in moulding and drying, it cannot make a good product finally unless it is well burned. In fact the process of burning has been so little developed, that it is treacherous in the extreme. The addition of a few pounds of coal to the fires at just the wrong time will spoil several hundreds of dollars worth of ware besides causing much extra labor in taking it out, due to its "run-together" condition. The writer has observed cases of this kind where several weeks of picking and sledging was necessary for the removal of the ware. It could have been removed under ordinary conditions in 10 to 15 hours.

The process of burning is divided into two stages in the common clay industry, but where the ware is vitrified there is a third stage added, namely that of vitrification.

1. During the watersmoking stage which is the first the ware is slowly heated to a point a little above the boiling point of water (generally 120 to 175°C) and is held at this temperature until all the mechanical or uncombined water has been driven out. The time spent in driving out all this water

varies greatly with different clays. The finer clays as a rule require a longer time. If the ware is heated to a higher temperature before all the water has vaporized the result will be cracks and, perhaps, explosions. 2. From this stage the burning may progress very rapidly until about 700°C. is reached, where in most clays the finely divided carbon begins to go off in ^{carbon dioxide} CO_2 by uniting with the oxygen of the entering air and gases of combustion. At this period the ware must be held until it is completely oxidized, or in other words, until a broken sample shows no black core, as the black center is called. If the temperature is raised much above this the outer cells become sealed, and since the gases from the carbon cannot get out therefore the pressure inside the piece is raised higher than that around the piece. This increase of pressure results in swelling the ware, and a spongy center is formed. This finely divided carbon exists in all clays in varying quantities, and is found in highest percentages in shales, which are the hardest to carry through this period safely. ~~In the~~ ordinary hollow wares the temperature is increased after the watersmoking has been finished to a temperature at which the burning is complete. Because of the thinness and consequently easy oxidization that may take place, no stop at the oxidization period is necessary except in very carboniferous shales. After the finishing temperature is reached in the top of the kiln, it is necessary to hold the heat at that point so that the heat may become distributed evenly throughout the kiln. 3 In wares for paving or sewer purposes there must be an impervious glaze or coating and

therefore the third stage comes in i. e., that of vitrification. In this stage the temperature is raised until the ware becomes glassy and is held there until a glassy fracture will be shown throughout the piece. A good clay for such purposes must have a long range of temperatures at which this will take place without melting. Where sewer pipe are salt glazed this vitrification does not take place throughout, but the salt gases from the volatilized salt in the fire boxes produces a surface reaction with the resulting glaze.

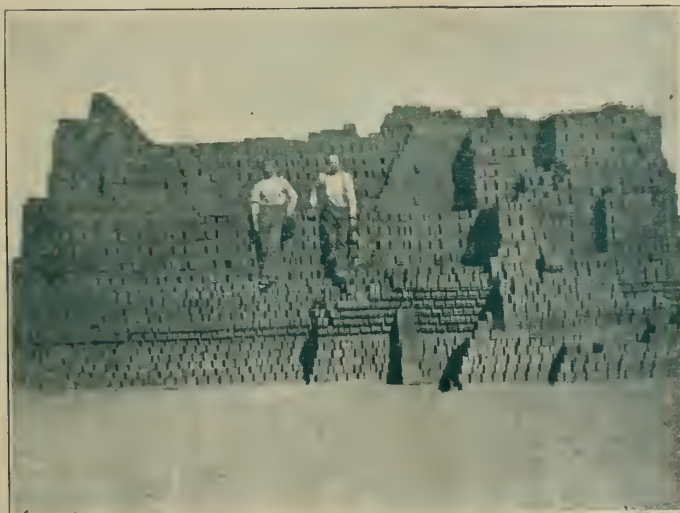
Kilns in which wares are burned have been divided in five general classes, 1, The up-draft. 2, The down-draft. 3, The continuous. 4, The semi-continuous. 5, The tunnel kiln. They will now be described in order. It will be noticed that in many respects some in one class are very similar to those in other classes.

1. UP-DRAFT.

We have methods of burning which might not properly be called modern, but which are at the same time being used in certain localities with such success that none of the other methods have succeeded in displacing them. Among the Catskill mountains and all along the Hudson river, as well as near Philadelphia, we see long lines of the old up-draft clamp kiln shown in figures 19 and 20. These have been used in that district for nearly a hundred years. They are of a temporary nature, and are really built around a large pile of brick, which are set so that fire can be kept in the arches composed of the

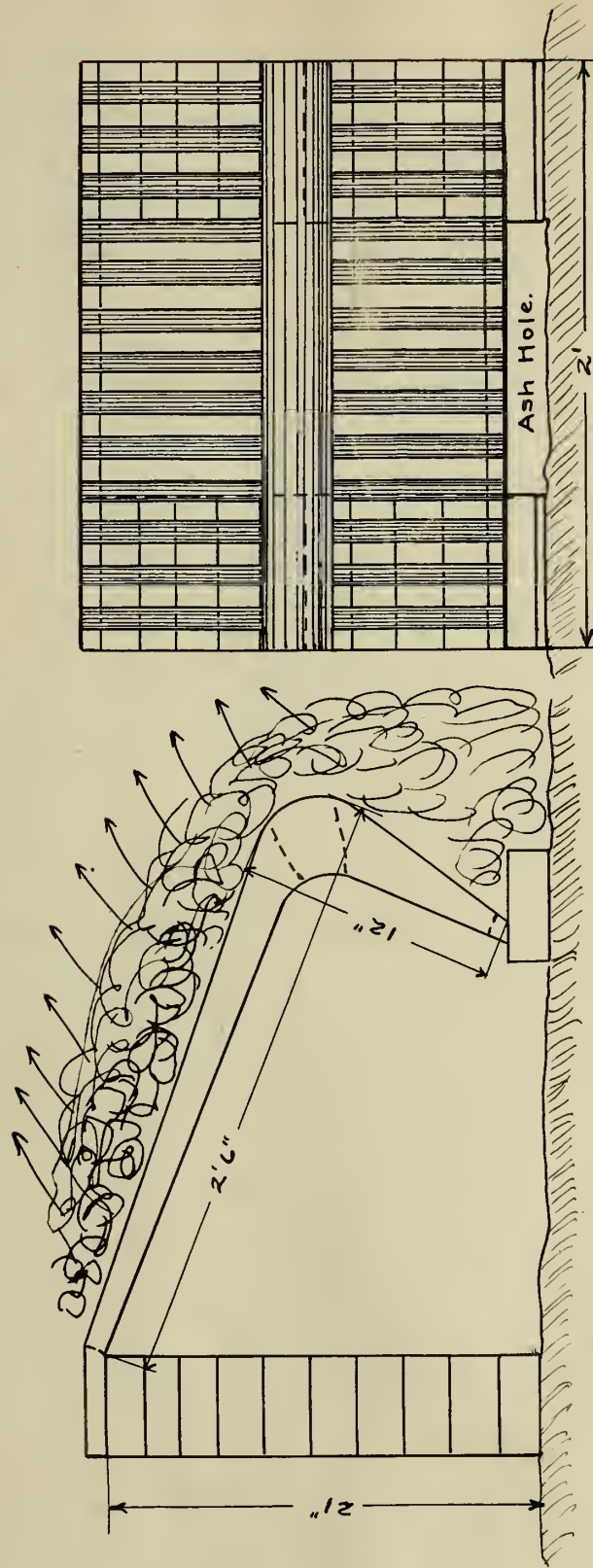


Clamp Kiln.
Fig. 19.



(After the Burn)

Setting of Clamp Kiln
Fig. 20.

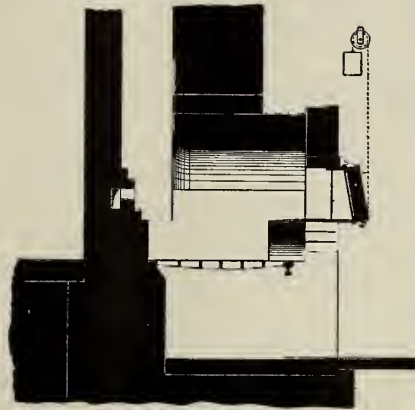


Two Views of Alsip and Hoyt's Clamp Kiln Grate.

Fig. 20 a.

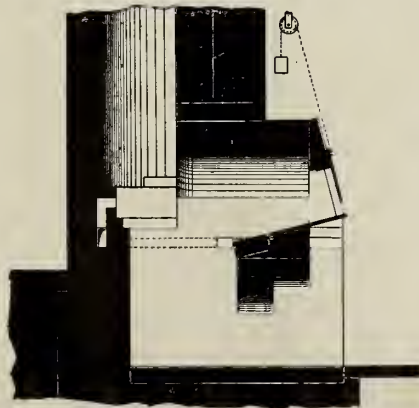
brick themselves. Since wood and high grades of coal is available in these regions, the practice has been kept up from father to son through several generations. Figures 19 and 20 show how the pile is made and how it is propped or clamped as it is called. These kilns are very wasteful in their use of the heat from the coal or wood since it is almost impossible to control the air so that a proper amount for combustion is admitted, because the walls are necessarily laid up very loose, and cracks are formed in them as the burn progresses. It is impossible to obtain good even results with such a kiln. Those over the arches are vitrified and those on top are soft and "punky" and the latter are only fit for backing in walls.

The next kiln which was used was the permanent wall rectangular kiln firing with the up-draft system generally called scove kiln. In these the side walls contain the furnaces which are generally of the horizontal grate bar type something like figure 21. These furnaces furnish heat for one, two or three arches, such as are found in the setting of the temporary clamp kilns as previously shown in figure 20. This kiln has the advantage over the clamp of a control on the air supply furnished to the combustion chamber. The furnace to two arches seems to give the best results, as to coal used, and results obtained. When a furnace to the arch is used, too much coal is used, and three arches to the furnace are used with rather indifferent success, because of the difficulty of giving to each its portion of the heat. This latter condition could be easily controlled were it not for the ever changing conditions



Furnace No. 13

Fig. 21.



Furnace No. 22

Down-draft Kiln Furnaces.

Fig. 22.

in the fire box, and as it is uneven results are the rule unless excessive care is taken in regulating the heat. The three arch to one furnace has a slightly greater economy in its use of fuel, due to the centralization of the fire. The draft in this kiln is due only to the heat going through the brick, and out the top of the pile. The draft is controlled by a course of loose brick laid close together upon the top of the pile.

This covering is called platting. When the kiln is started,

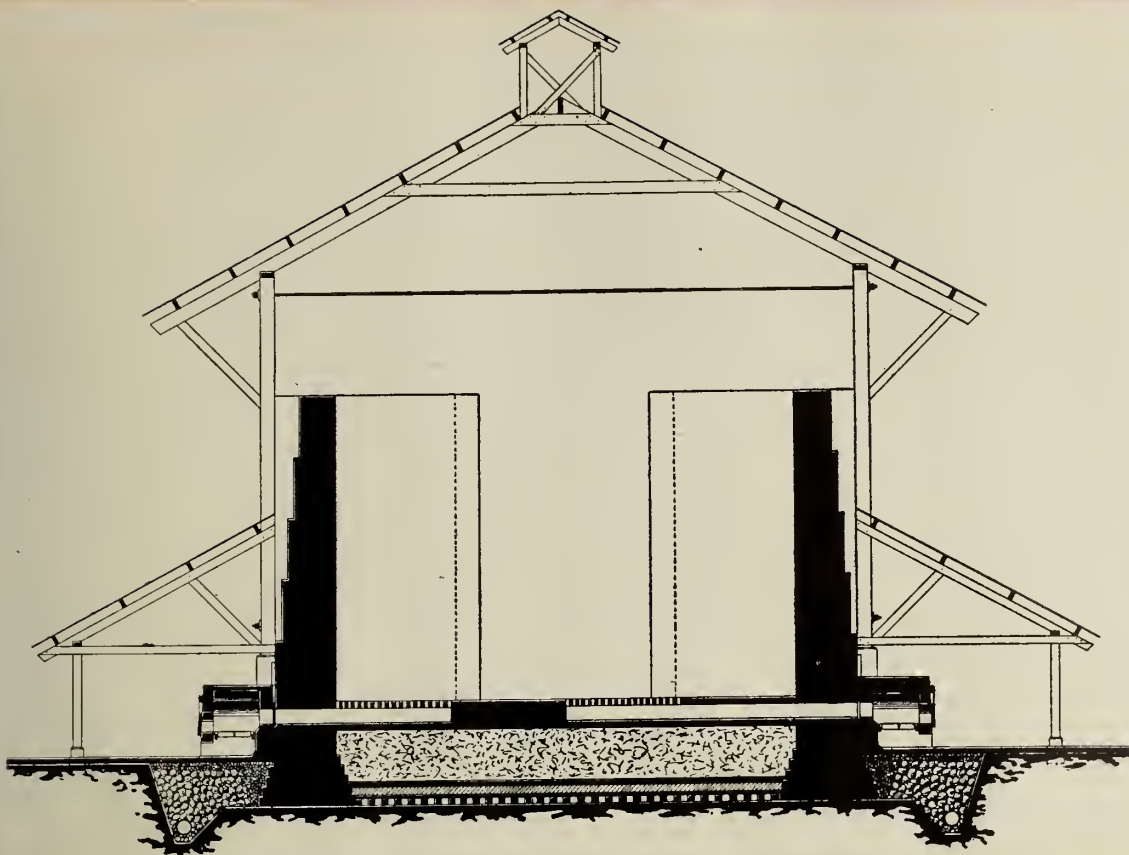
some of the brick are removed, and as the heat advances up toward the top, and the draft becomes stronger, the same brick are laid back in the places from which they were taken. Toward the latter end of the burn, the cracks between the brick are too large to sufficiently damper the draft, and, therefore, a covering of fine ashes is applied. In some localities, where the setting is not uniform, the distances between the bricks in the setting varies so much that cold spots are formed, due to the gases going out along the path of least resistance. As the heat becomes more intense the temperature difference becomes greater. The only way of remedying this fault is to cease firing, and remove the platting over the high spots on top, which indicate these cold spots due to less shrinkage. The heat is then radiated from the surrounding brick, and drawn through the colder ones, until the desired settle is secured, and the firing may go on. Many ways of setting the brick are in common use. The brick may be set two over two with the upper two crossed at an angle of 90° with the lower ones. If the bricks do not shrink much in burning, so that they will

not tip or roll as they shrink, they may be set two over four where the four are two deep and parallel. Other ways used are four over five where four brick in a cross position cover five. In face brick manufacture, in which may be used any method of burning, one brick must be placed directly over another, so that for every two there are two faces which contain no kiln marks or indentations due to crossing in setting a few other methods of setting in these kilns have been used by certain manufactures, who have found them best suited by experiment for their certain clay.

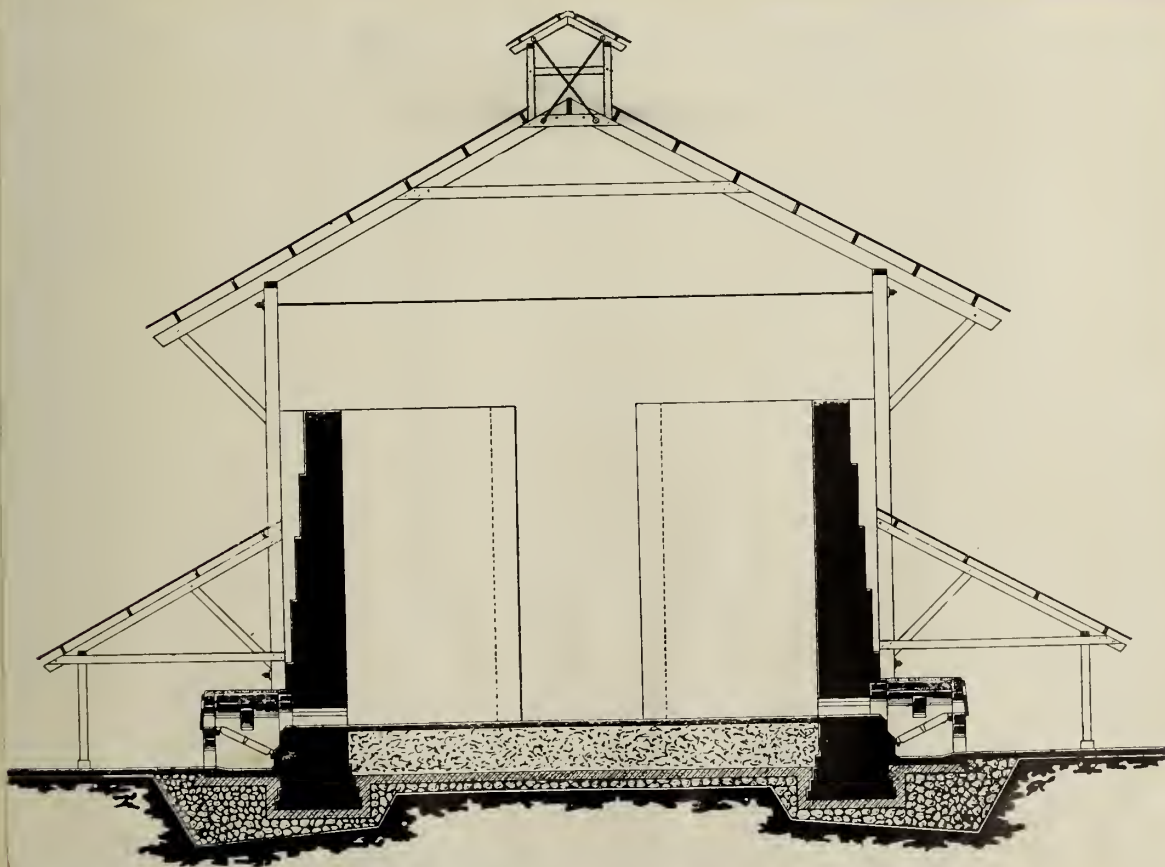
The up-draft kiln (figures 23 and 24) is very wasteful in the use of heat particularly in radiation from side walls and top, and, if used, should be made with good insulation between double outside walls. They cannot be expected to give fine uniform results, because of their basic principle. They are, however, a cheap kiln to construct, and maintain, as well as fill, and empty, and, for a small plant with little available capital, they are the only alternative. Examples of this kiln may be seen at the Stipes and Barr yards in Urbana, Illinois.

2. DOWN DRAFT KILNS.

The down-draft kiln is the one most used in this country by clayworkers, and is adaptable to all kinds, qualities and weights of wares. The principle of this kiln is that of the down draft furnace. The gases enter the kiln near the top instead of the bottom, as in the up-draft, and are drawn down.



THE RICHARDSON-LOVEJOY UP-DRAFT KILN WITH BOTTOM FLUES
KILN NO. 8



THE RICHARDSON-LOVEJOY UP-DRAFT KILN WITHOUT BOTTOM FLUES
KILN NO. 6

Fig 23 and 24.

The flash wall or bag wall, which are really only ducts leading from the furnace, carry these gases up, and into the top. The height of these walls must be such that the gases are kept from coming in contact with the ware until they have been spread out and evenly mixed. The gases are then sucked downward through the ware by the chimney draft, and pass out through vents in the floor. The idea in mind in this system being that the hottest ware is on the top, and therefore is not subjected to the load that the ware lower down must carry. Too high a degree of temperature in the kiln for a short time is therefore not as disastrous as in the up-draft kiln where the hottest ware is at the bottom. These down draft kilns may be divided into two general classes namely: 1. The round kiln. 2. The rectangular types.

1. The round down-draft kiln is built in diameters of 18' to 40' inside the walls. The smaller are used for the finer face brick industry, while the larger diameter of 40' has been used with rather indifferent success in the paving brick industry. The largest kilns have the advantage of less loss due to radiation per unit of ware burned than for a like burn in the smaller kilns. The usual size, however, found in the brick and tile industry varies from 24' to 30' inside diameter. In these kilns the heat is easily gotten down, if the fireman has sufficient draft at his command, and an even burn is generally the result, if the flue system has been designed correctly. Due to the kiln building being done largely by the man who has learned all his sizes of flues, flue-boxes, stack, and

other parts from experience, very little data can be secured, by the "green" manufactures, concerning kilns. An application of scientific principles has not been tried by anyone so far, and there is great chance for advancement along these lines.

The furnaces of the round down-draft kilns are of two general types i. e. 1. The grated type. 2. The grateless type.

1. In the grated furnace, the grates may be sloping or horizontal. The sloping furnace consists of steel bars about 1/2 inch by 2 inches in cross-section, and from 2 inches to 3 feet long, with one end bent to form a hook. The lower end is laid upon a steel cross bar (figure 26) while the upper end is hooked upon a similar cross bar at the upper end. The cross bars hold the grate bars in place at an angle of 45° to 60° from the horizontal. The lower end does not reach to the furnace floor by about one foot. This space below furnishes a very convenient place for the removal of clinkers. In firing the coal is thrown into the upper end, and slides down the grates to the bottom, as it burns. In watersmoking, the fires are kept low and allow a great quantity of superfluous air to enter. As the moisture of the brick is driven out the temperature in the furnace is raised by gradually allowing ashes and fuel to accumulate until the furnace becomes filled. The hottest fire is obtained when the whole mouth of the furnace (above the grates) is entirely filled. The only air the fire gets at this hottest period must come through the grate bars. The cold air coming through the bars keeps them, and the clink-

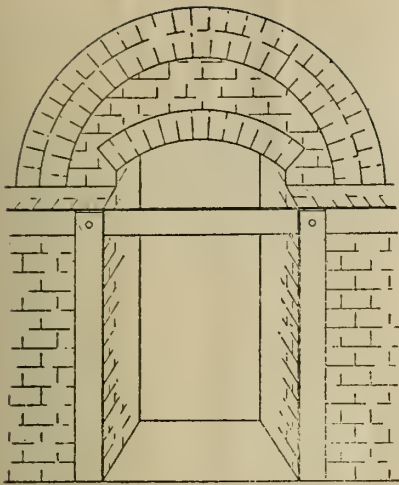


Fig. 25.—Old-Style Furnace.

Fig 25.

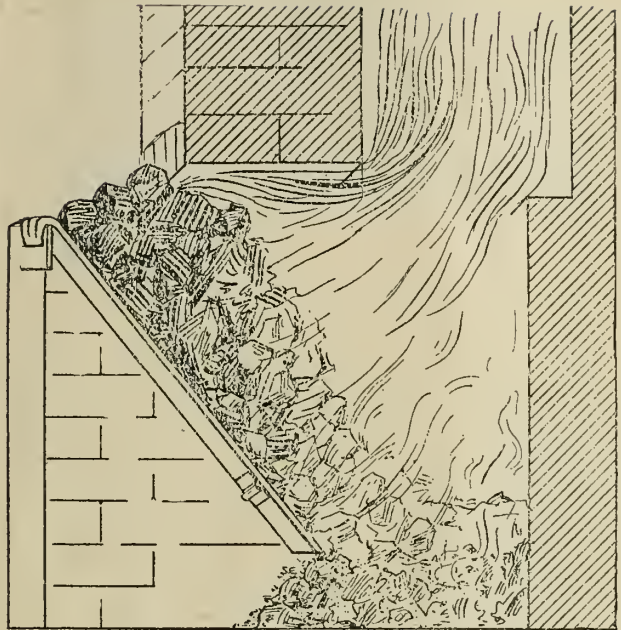


Fig. 26.—Faulty Conditions for Combustion.

Fig 26.

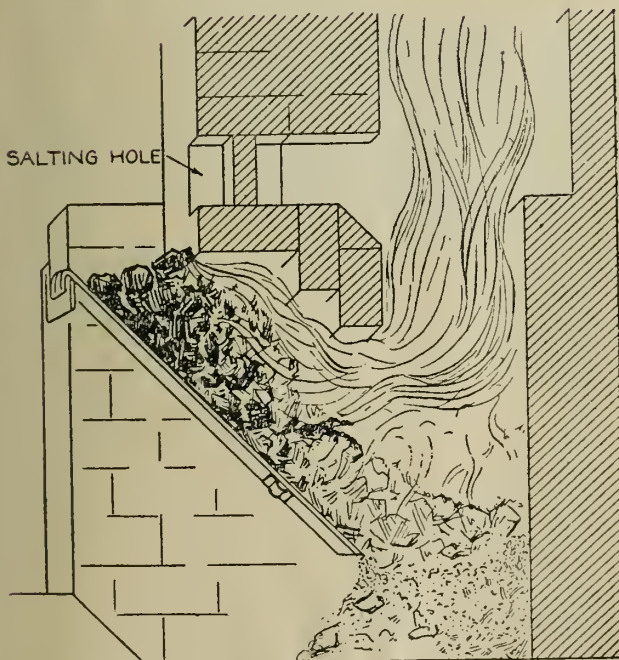
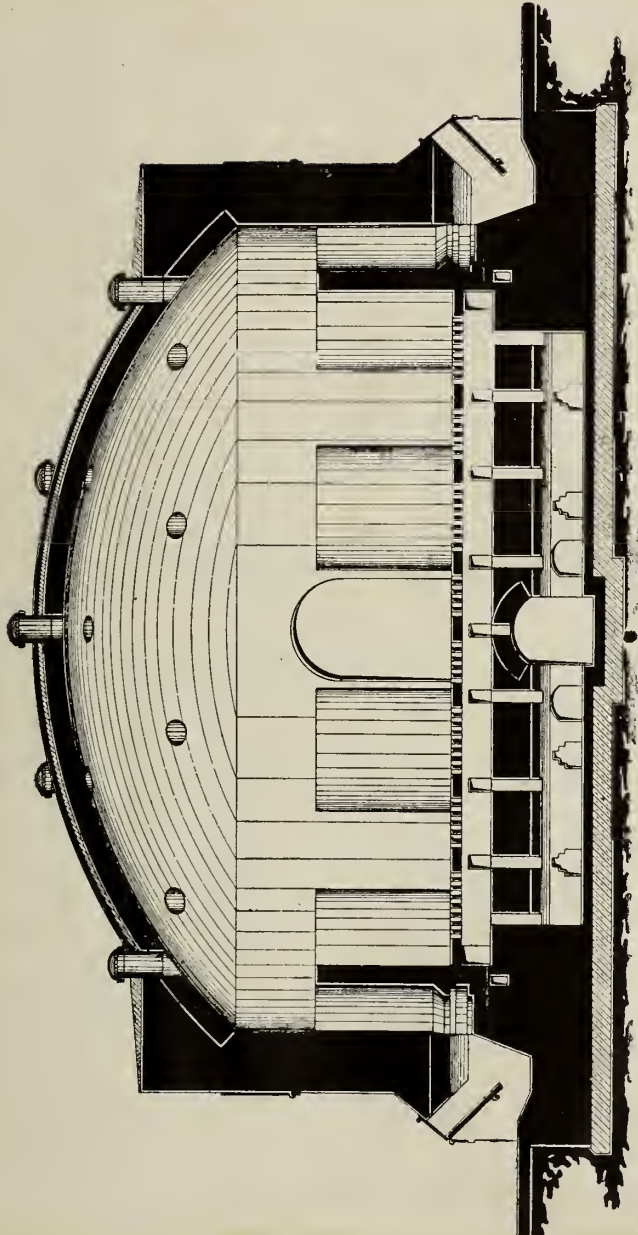


Fig. 27.—Improved Conditions of Combustion in Altered Furnace.

Fig. 27.



THE RICHARDSON-LOVEJOY ROUND KILN WITH OUTSIDE STACK.
KILN NO. 12

Fig. 28.

ers over them, cool and therefore no trouble is experienced from sticking. Instead of the bars as shown in figure 27 an arch may be used upon which the coal rolls down. These furnaces are very unsatisfactory in some places, because of the lack of control which may be had over the temperature. They are very wasteful of coal, and thus prohibit their use in places except where coal is cheap. In fact, the ashes from these furnaces are so full of fine coal that considerable trouble is often experienced from the ash pile catching fire. The question was brought up before the 1907 meeting of the Illinois Clayworkers Convention of the possibility of burning these ashes under a boiler with a forced draft. Why not install better furnaces and let an initial firing do the work? Such furnaces vary greatly in dimentions, and no statement can be made concerning their size which will cover all cases. A few under the writers observation give an average of 2 1/2 feet in width, 3 1/2 feet in depth (from spring of arch to floor) and 3 feet from the front edge of the grates to the rag wall at the back of the fire-box, which deflects the gases upward. Variations of grates are also found in the sloping grate furnaces. At times the slotted cast grates have been set upon a similar slope, and even a rocker grate is sometimes installed in like manner. These two last cases are generally set at a flatter slope than the hook and grate bars. These two last cases are much more expensive to install in cases where they can be used than the first mentioned hook and bars and are really little better.

See figure 28 for example.

2. The horizontal grate bar furnace is much the same in respect to supports, side walls, and doors as those found under the ordinary hand fired boilers. Ash doors are provided by some kiln builders, but their use is not general. The grates may be of stationary or rocker type, and are generally not over 4 feet in length by 2 to 3 feet in breadth, giving an average of 8 square feet floor area to 1 square foot of grate area. The sides of the firebox, and the arch over the same must be of a very high grade of refractory brick because of the most intense heat, (1500° to 2200°C) which must be maintained in the furnace. The spring of the arch is generally 12 inches to 18 inches above the grates. The arch which has been found best for combustion and which also stand well has been found to have a radius of 28 inches to 32 inches. Doors for furnaces are generally of iron with the common perforated protecting plate but others are in common use. A door made up of ordinary fire brick which are held together by a strip of steel passing around the whole is often swung with a wire of 12 feet to 15 feet in length and hung over the furnace opening. Such a door is not as tight as a good cast door. Another door made by the Dunlap Manufacturing Co. of Bloomington, Illinois is made of one piece of circular fire clay held together by an iron band. This door rolls back on a grooved track made especially for the purpose. This door is easy to manipulate and lasts a long time but is open to the same objection as the other brick doors above mentioned. Cast doors

with fire brick linings are sometimes used.

Coking tables are frequently used in combination with these horizontal bar furnaces, in cases where the coals are high in hydrocarbons. The coaking tables are situated so that the green coal thrown upon them is bathed in the highly heated gases from the hottest of the fire, and its volatile constituents driven out are burned at once, instead of going into the kiln where the temperature is not high enough in most cases to cause complete combustion. Such furnaces are patented and sold by two companies.

1. The Swift furnace has an elevated ~~coaking~~ table between two grates with a fire door for the table and a stoking hole for each of the grates. A charge is thrown upon the table by the fireman, and, after he has fired around the kiln (generally 8 to 12 furnaces), which generally takes about 5 minutes, he throws the coal to each side with a slice bar and thus prepares the table for another charge.

2. The Grath patent is on the same principle as the above, but has two tables instead of one. The two tables feed but one furnace, which is situated between the two tables, and about 8 inches below them. This patent is best adapted to coal which does not clinker badly. The Swift is best for the common Illinois and Iowa coals.

The Boss furnace is fired with a forced draft. The front of the furnace is entirely closed with the exception of a fire door. The necessary air for combustion is blown through

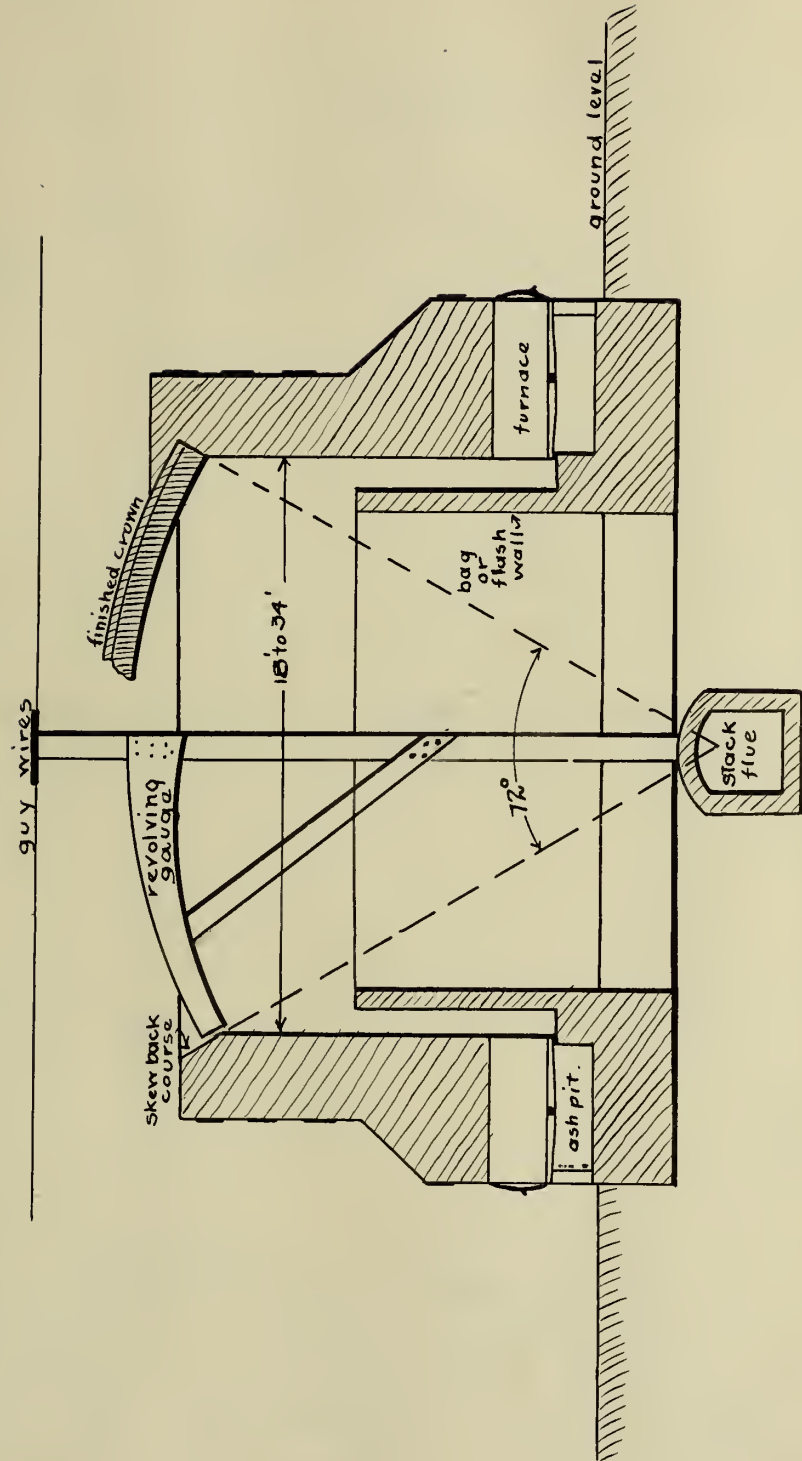
the grates under a pressure of 4 ounces to the square inch. This air is furnished to the separate kilns through main ducts. Each kiln has suitable branch ducts for providing and regulating a supply of air for each furnace. This system has the advantage of being independent of weather conditions but does not work well in a sulphurous coal because of clinkers running into the air holes of the grates.

The bag walls or flash walls at the back of each furnace prevents the highly heated gases from coming in direct contact with the ware as the gases enter kiln chamber. As the gases leave the furnace, they are deflected upward to the crown or arch covering the kiln, and then are drawn downward by the draft created by the stack. The height of the bag may vary from 5 feet to 6 1/2 feet above the floor i. e., from 3 1/2 to 5 feet above the grates of the grated furnace. The only difference between the bag wall and flash wall is that in the first the walls are built rectangular or semi-circular around the back end of the furnace opening in the kiln, while the second is a continuous wall built out at a distance of 6 inches to 8 inches from the inside kiln wall. The flash wall is tied into the inner wall of the kiln. The height of both vary in the same proportion as above mentioned. The flash wall has the advantage of less repairs than is necessary in the bag walls. In some paving brick kilns the flash wall is flush with the inside kiln wall, and the furnace gas duct is submerged in the wall of the kiln. This wall has the advantage of less liability

to collapse and greater ease in setting but has also the disadvantage of making necessary a much heavier construction of wall because of the gas ducts. A large part of the repairs in kilns is on these deflector walls and furnaces and are really the weakest parts in kiln construction. In building these parts the expansion and contraction as well as the necessary refractory qualities of the material of construction should be carried in mind, because of great changes of heat and high temperatures encountered.

The next thing to be taken into account in down-draft kiln construction is the crown. This part of the kiln is held in place by preventing lateral displacement of the outer wall by bands of 6 inches widths of $3/16$ inch steel placed at intervals of 6 inch to 10 inch on the outside wall, or a single band 28 inches to 36 inches in width. The crown is sometimes made by using a form of the segment of a sphere, but is more often laid with a finger of a segment of a circle, which is fastened to a central post in the kiln, and is so constructed that it may be revolved around so as to take in the whole area of top. When this latter method is used the first course is laid upon skew-backs, which have been laid in the vertical wall, so as to give a suitable foundation for the crown. The courses are then laid slanting, and at a constantly increasing angle from the horizontal, until the center of the kiln is reached, where the brick courses are almost vertical. The brick are laid in fire clay a mortar of common clay and sand, so that the bottoms as they stand in the course have no mortar to speak

of between them, and the tops have quite a thick joint on all sides. A wedge is thus formed from ordinary building brick or rectangular fire brick, which in combination with the other brick of the crown cannot fall in as long as it holds its general shape, and no lateral displacement of the vertical walls is allowed. There are cases where one side has been heated to too high a temperature, and the brick, becoming softened, are unable to withstand the pressure brought to bear upon them by the other courses bulge up, and allow the other side to fall in. The form of the arch is kept true during its erection by the finger as above mentioned by which each brick is gauged as it is laid into its place. In most cases ordinary shale brick are used in crowns, but in cases where these are not refractory enough fire brick must be used. In making crowns of fire brick, it is well to remember that special shapes are no more expensive than those of ordinary shapes, and that a little better crown can be made from them. These special shapes are also easier to lay and require less mortar. The rise of the kiln crown is often used in talking of kilns. It is the vertical distance from the spring of the arch to the inner ends of the central brick. Rises of 1 foot to every 5 feet inside diameter are most common. For a 30 foot kiln a rise of 6 feet is therefore proper. Some kilns have greater rises in their crowns, but experiences show that a higher crown does not keep its shape so well as the flat ones and besides prevents a quick heating up of the kiln because of the difficulty of getting the heat down. An extremely flat crown is best in



Details of Kiln Construction.
Fig. 29.

this last respect, but is very bard to hold up. Latest designs in kiln building have had crowns of a construction after the principle involved in figure 29 in which the shape of the crown is determined by the 72° angle between the skew-backs.

FLOOR AND FLUE SYSTEMS.

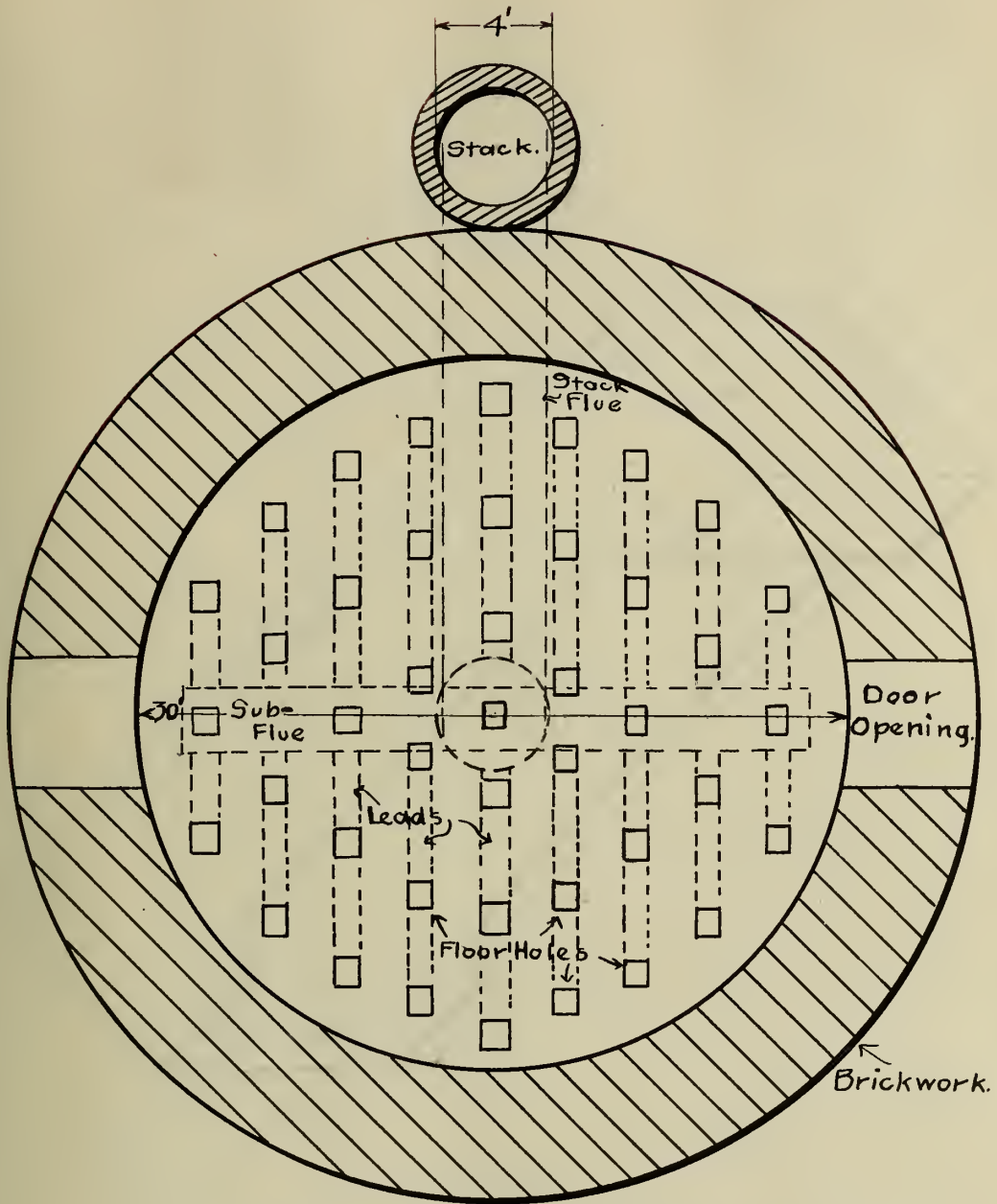
After the crown the next part of the kiln the gases come in contact with is the floor and under flue system which is so varied in all cases that only a few of the best systems can be given. Each ware of a particular clay has a floor and flue system which seems best suited to turn it over. The solid floor is the simplest and in some cases the most effective. It consists of a single tapering flue run as a large diameter across the kiln with holes about 6 inches by 12 inches to 36 inches in dimentions running across the flue in the floor at intervals of 1 foot to 2 feet. The flue is tapering, and may be about 3 feet by 3 feet at the stack end while it may run to as small as 18 inches by 18 inches at the opposite end.

The next modification we find is the T-flue system. The T-flue is laid out symetrically with respect to the stack. Holes similar in dimentions to the above are in the floor. The floor is paved with brick, or filled with fine cinders. These two systems are used ^{generally} in the manufacture of the poorer grades of building brick, where the color or degree of hardness within certain limits does not matter. Certain paving brick companies use these floors because of the ease with which they can be cleaned of the sand used to prevent sticking. The

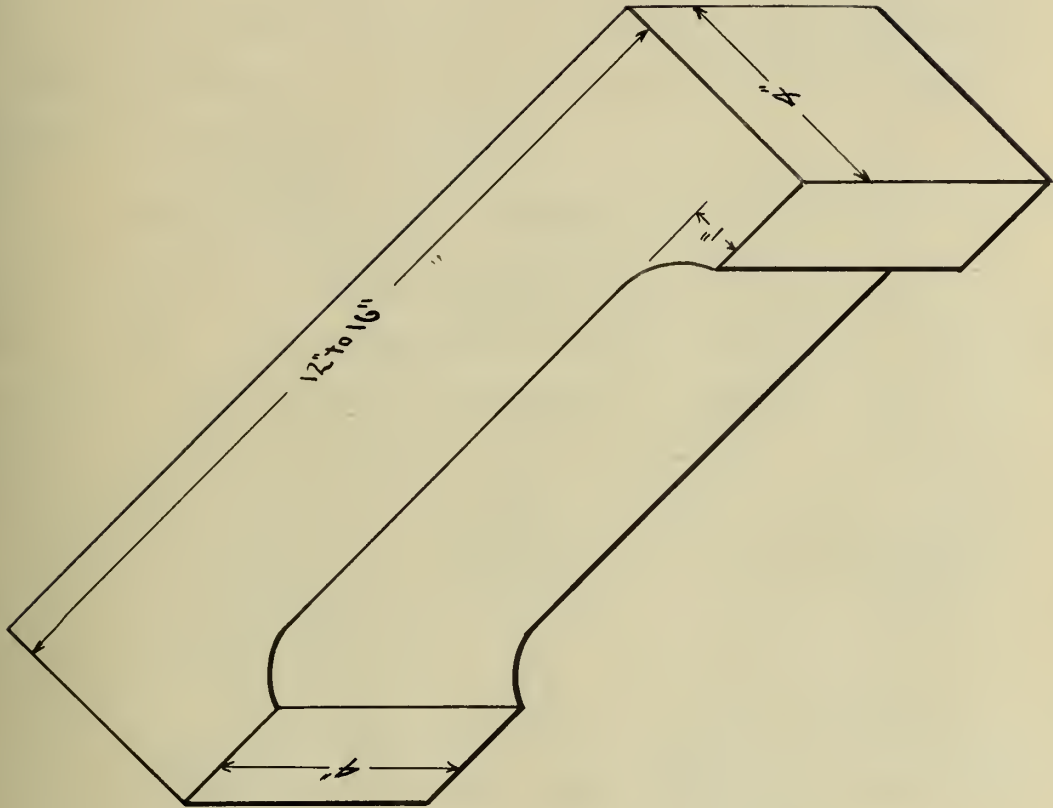
Chicago brick yards are good examples of the "any old way" burn, in fact it has been said that Chicago brick are not burned but only baked. This does not matter so much in that locality because nearly all the brick produced are used as backing in the large steel frame buildings.

The next flue system met with is the solid floor with multiple branches shown in figure 30. These are also used extensively in the paving brick industry for the same reason as mentioned in connection with the above. Such a floor can be used in the manufacture of tile and sewer pipe, but others are in use which give quicker and more uniform results.

The radial flue system is used a great deal in this country because of its ease of construction. The flues lead to a central well from which the stack flue leads. The radial flues extend almost to the inner wall of the kiln, and may be tapered or not. Such flues are generally 2 feet deep and 6 to 8 inches in breadth. These flues are covered with brick made especially for the purpose. These brick (figure 31) are from 12 to 16 inches long, and generally 4 inches by 4 inches on the ends. On one side a portion of the brick was cut away leaving the ends the same for about 3 inches back. When the brick are laid in the floor over the flues, this space between them, because of the cut out portion, leaves sufficient opening into the flues for the escape of the gases and makes a very substantial part of the floor. In some places, where dry-press brick are made, this floor is modified by running numerous



Floor Plan of Multiple Flue
Down Draft Kilm.
Fig. 30.

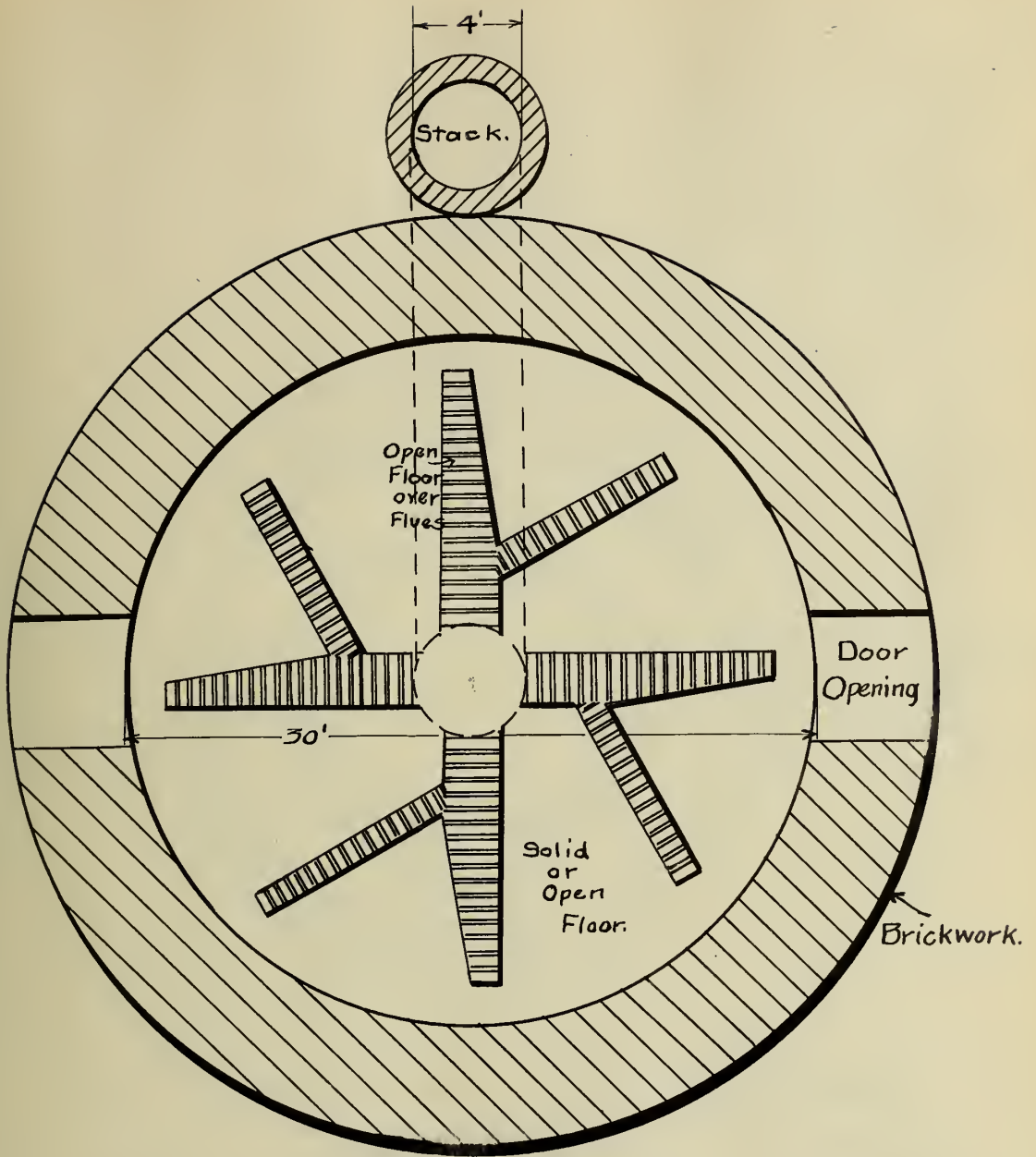


Floor brick generally used in kiln construction.
Fig. 31.

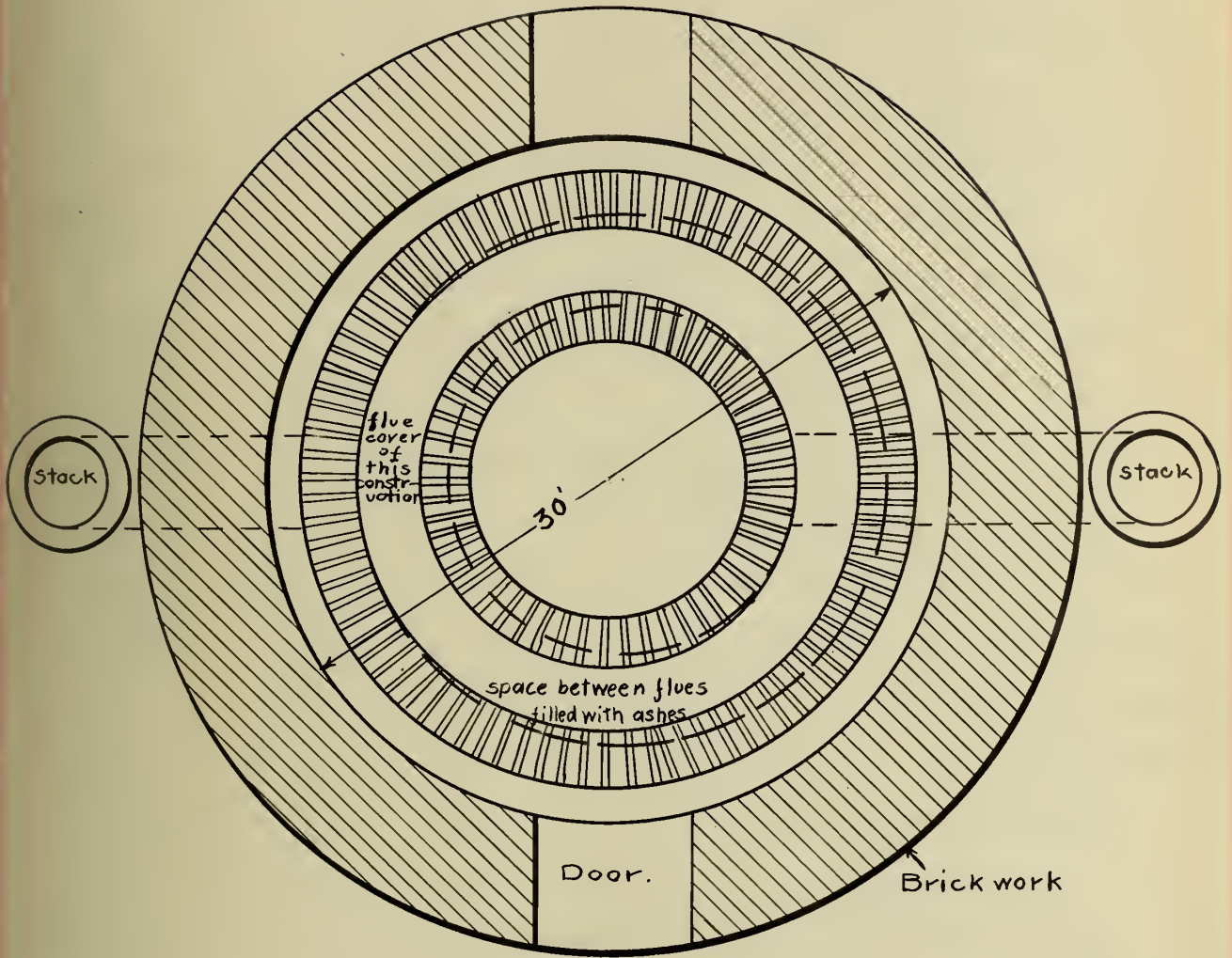
small flues from the radial flues, and covering the small flues with the floor brick. Thus an almost entirely open brick floor is used, and a very free passage from the bottom of the kiln is obtained. This is quite necessary in the dry-press process because all the moisture is removed while the brick are in the kiln which although not above 6% of mechanical water, and 5% of chemical water, ~~X~~ is enough to make the brick shaky if allowed to remain near them.

The Y radial flue (figure 32) is one that is used a great deal in sewer tile manufacture, because of the evenness of draft over the entire bottom of the kiln. In this system the stem of the Y leads into a central draft hole, and goes out radial from that. The branch leads off to that part of the floor which lies between the radial branches, and which has become so widened out near the wall that it is hard to get an even heat down unless some such branch is run out. Such a system has been used successfully in the manufacture of hollow ware. This system is sometimes used as the basis for other small branch ducts making the floor entirely of open brickwork in place of just above the Y's.

The double concentric ring flue (figure 33) system is one of the latest of all systems used. It was first introduced by Mr. A. S. Smith of Mason City, Iowa. In this system there are two ring flues one of which is near the inside wall of the kiln while the other is near the center. Figure 33 shows the location of these flues. When designing such a floor



Floor Plan of Y Flue
Down-Draft Kiln.
Fig. 32.



Floor Plan of Ring Flue
Down - Draft Kiln.
Fig. 33.

each flue is given equal areas per foot of flue length. The draft in these two flues is secured from two stacks placed diametrically opposite. One stack draws from the outer flue, and the other from the inner. By means of dampers a most perfect control is always had over the burning. A disadvantage of this system is the necessity of having two stacks in place of one. In place of the two stacks a common arrangement which gives better draft and yet a little more even burn is to have six to eight small stacks in the kiln walls which are attached alternately to the inner and outer flue. Such stacks need not extend very much above the tops of the kiln wall (not over 8 to 10 feet). The disadvantage of using the multiple stack system when built in the walls is the great and unequal expansion caused in the walls as the kiln becomes heated. This cracks the walls, and makes them very difficult to hold together.

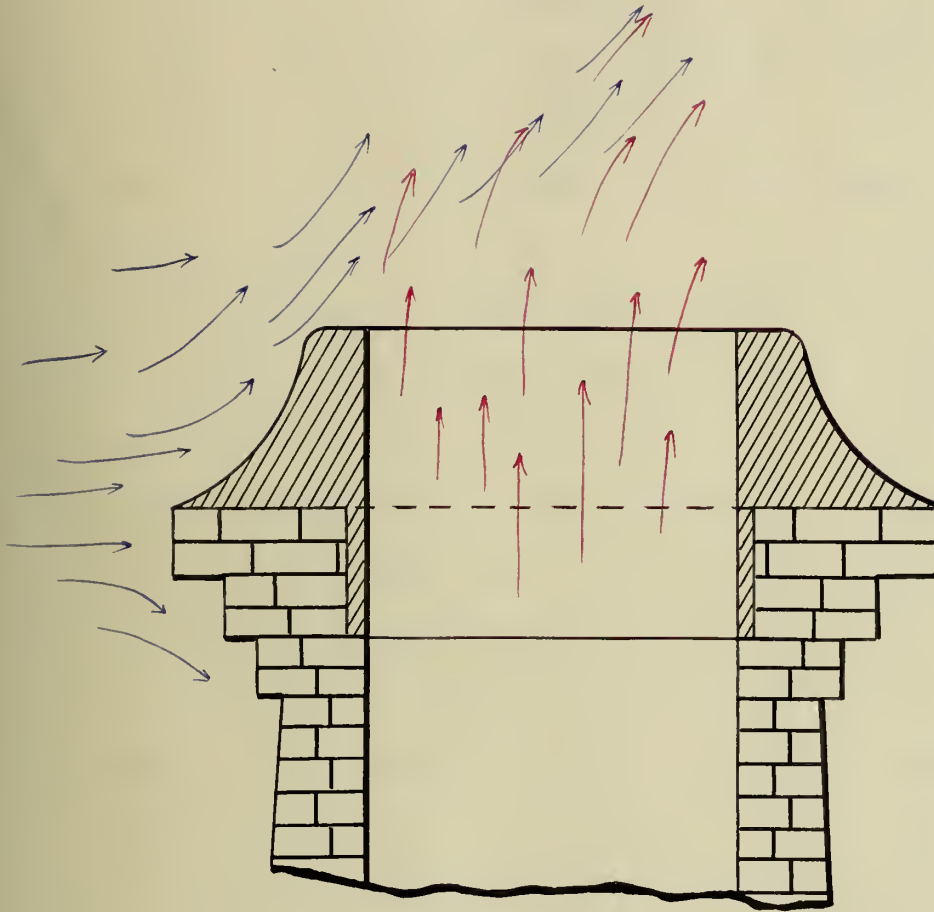
The stack is placed in the center of the kiln in some applications of any of the above flue systems. The advantage is a better draft to start the kiln with, because of a warm stack being had to start with. Such a stack interferes with the setting of the kiln, however, and is therefore not used to any large extent except in the manufacture of terra cotta.

In some cases, where it has been found very difficult to drive the heat to the bottom of the kiln, a flue system has been designed in such a manner that the fire may be caused to either go up through the bag wall, or down underneath the floor and up through the ware. By changing frequently during

the burn from one system to the other, a even heat throughout the kiln may be secured.

b. The rectangular down draft kiln is similar in principle to the round kiln of the same draft. Instead of being held together by bands, it has trussed bracing, which is held by long cross-rods. The furnaces used in the round kiln are also used in this kiln. The bag walls are exactly the same in reference to the furnaces. The flue system almost universally used has a long central flue through the center the entire length of the kiln wall. In most of these kilns the floor is of open floor brick covering only over the flues, although, in some cases, these kilns have the entire floor laid with the special floor brick. In the paving brick industry the first mentioned floor is used because where sand is used and generally a paving brick manufacture would ^{not} think of trying to burn without the sand sprinkling between the courses, the floors must be cleaned each burn, and the flues at least every other time. If the entire floor was left open, the cleaning would be necessary each time. In some kilns of this type an end stack furnishes draft for the entire flue, while in others a stack at each end takes its share of the draft load, and yet on other very long kilns are found three stacks (one at each end and one on one side at the middle). Where there are three stacks the flue is divided into three parts. The central part receives its draft from the side stack.

All rectangular kilns are hard to keep in shape, and must, therefore be most thoroughly braced, and provided with



Wind Action
on
Chimney Tops
Fig. 34.

expansion joints. The greatest difficulty in providing for expansion of these kiln crowns was encountered in the first days of these kilns. Where no provision was made the crown or arch as it is more properly called in this kiln would buckle and give way. When they did not buckle they pushed the end walls out, and in that way spoiled the kiln, for these walls once pushed out cannot be brought back into shape easily, because of their heavy construction. To prevent this buckling, or damage to the walls a most simple provision of expansion joints was made. The arch was built in several sections of 20 to 30 feet to a section with several inches between the sections. All the arches were then covered over with a single layer of brick laid upon their side. This latter added covering was called platting the same as that of the up-draft kiln. The brick laid upon their side were latter bonded together by a grouting of their cement and sand mixed about one-half to one-half. The inner arch or arch proper must of necessity become very hot while the platting does not undergo much change of temperature due to the excellent chance for the radiation of the heat passing into it. The arch therefore expands under the platting, and closes the joints as it reaches its highest temperature. There is no really satisfactory way of providing for expansion in the side walls. The only way in use at present is to make the walls of such heavy construction that no material damage is done to the kiln if the walls are cracked a little. A good bond also is very necessary in such walls. There are

three bonds in use today.

1. The Flemish bond is the best for kiln building. In this bond there is a course of headers to every course of stretchers.

2. The English bond has but one course of headers to every two courses of stretchers.

3. The American bond, which can scarcely be called a bond at all in kiln construction, has a course of headers to every 6 or 7 courses of stretchers. The best mortar for kiln work is composed of a half lime and a half portland cement for the outside courses and is used in the wall as far as the heat is not above about 500°C. Above this temperature this mortar will be decomposed and a fire clay brick must be used laid in a fire clay mortar of the same material from which the brick were made. This fire clay mortar if spread very thinly will become so fused into the brick that after the kiln has been burned a few times the whole interior of the kiln is almost of one piece. Of course this statement cannot be said to hold in all cases for in the burning of many wares the heat is not intense enough to produce the vitrification necessary.

There are several schemes upon the market which provide for the use of waste heat for heating of air furnished to the furnaces or for watersmoking the dry ware.

The Kaul system has a fan which draws the heated air from the cooling kilns through ducts laid under the floors of kilns, and under the ground to the combustion chambers of the

burning kiln. This same kiln after its burn is off is cooled by being similarly attached to other kilns. Quite a saving of fuel (often as high as 30%) may be realized by the use of this system. Since it is impossible to set round and rectangular kilns very close together the loss of heat in long flues is great, and it is in this point that continuous kilns have the advantage over all systems used in connection with this preheating or advance heating systems, or any other system which may be similar in principle.

The Swift system as shown in figure 35 uses this same principle in a semi-continuous kiln. The waste heat was described in drying and the preheating will be described under semi-continuous kilns.

3. CONTINUOUS KILNS.

The continuous kiln is a series of compartments or chambers so built that there is some part of the kiln being burned all the time. This means that there is some part of the kiln being burned all the time. This means that there is some part cooling while another part is being fired, and yet another is being heated up beyond which others are being filled and emptied. In order to accomplish this a long series of chambers must be built, and, in order that, the process may be absolutely continuous the chambers must be arranged in some such a manner that the fire always is going ahead, and around. The first kiln to be built on this system was the most practical of all continuous kilns ever built up to within a very few years ago.

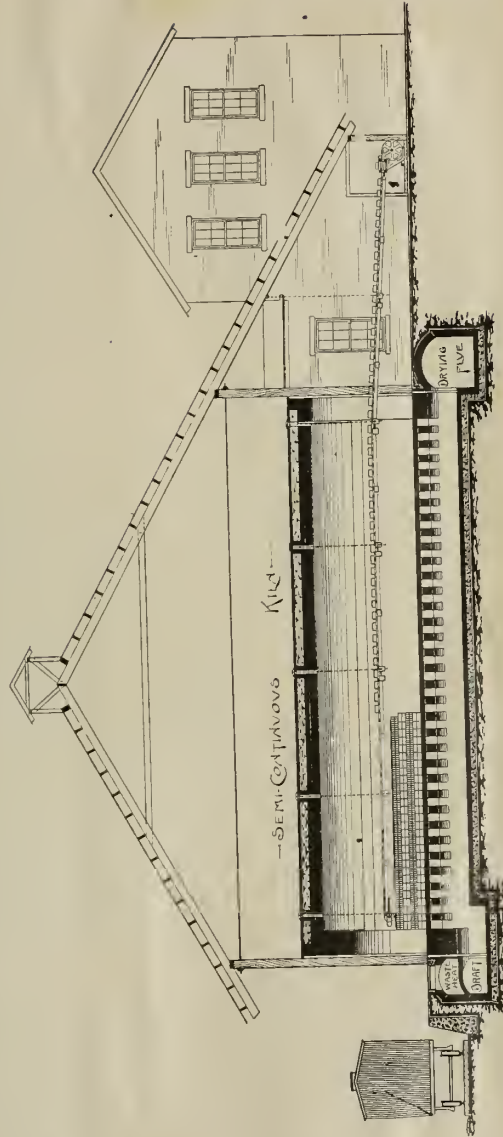
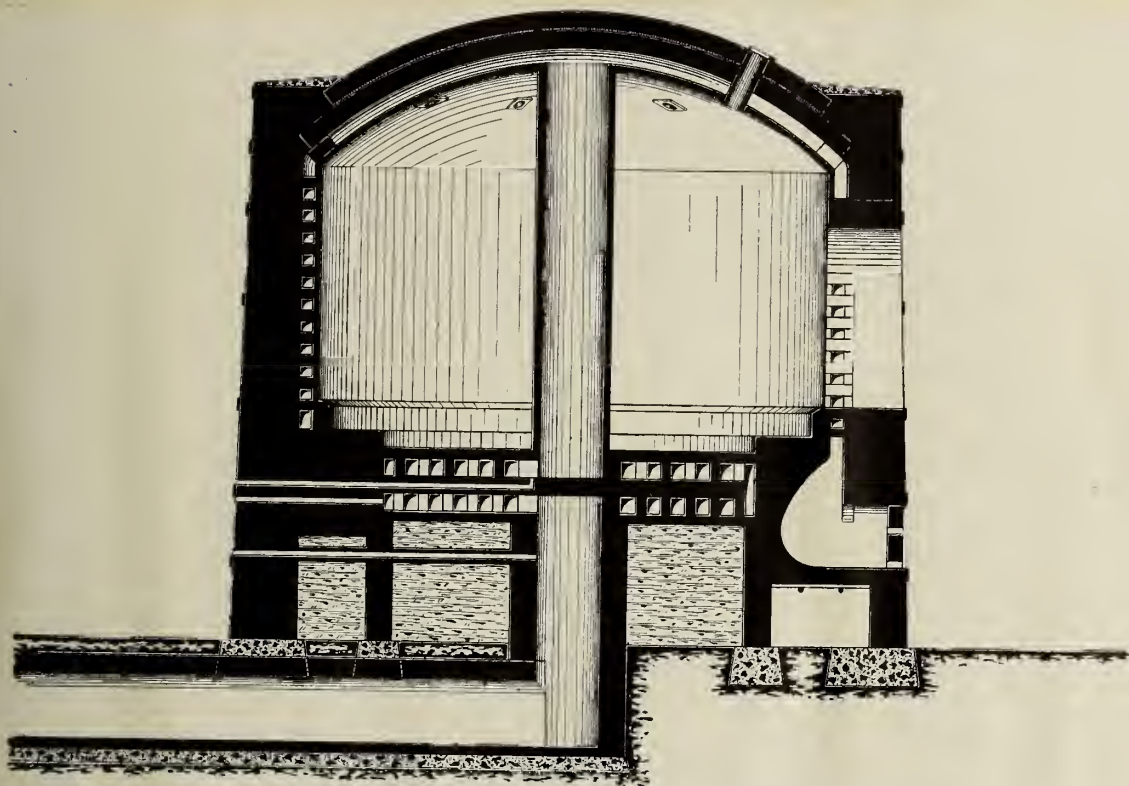


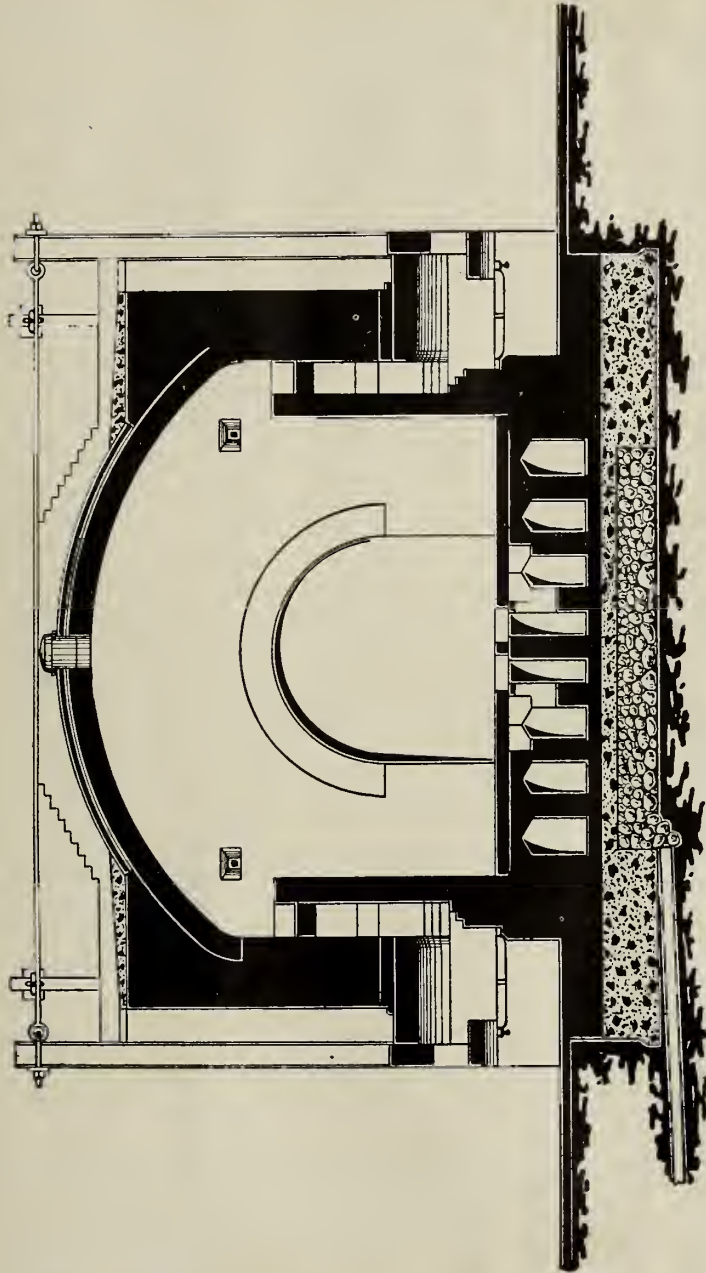
FIG. 5.

Kiln Used in Scott's Process
Fig. 35.



THE RICHARDSON-LOVEJOY OIL FIRED MUFFLE KILN
KILN NO. 41

Fig. 36.



RICHARDSON-LOVEJOY SQUARE DOWN DRAFT KILN.
KILN NO. 24

Fig. 37.

This kiln was built by Carl Hoffman a German engineer in 1846 near Berlin, and was called by the Germans ring-oven because of its annular shape. This form had an interior court with the stack in the center of the court. This disadvantage of this court was easily seen to be the space occupied by the kiln and the long stack draft flues. The kiln was then built oval in shape without the interior court, and was found to be more economical. After each days setting of green ware, a heavy brown paper especially made by the inventor was pasted over the surface of the finished setting, so that no air could get through either way. The burned ware was also being removed at the same time, in the tunnel, which extended around the kiln. Generally not over 40 feet is allowed to be emptied between the faces of the unburned and burned settings. The air which enters the door through which the material is being taken in, and out, goes into the burned setting, and through ware which is constantly being cooled by giving its heat to the passing cooler air. As the air passes through, and onward, it strikes warmer ware which is also being constantly cooled until it reaches the firing zone. In firing this kiln, the coal is dropped down through small overhead firing holes at intervals of 3 feet each way in the arch. The coal falls in among the wares, which have been set so that as the coal falls, a part of it will be retained here and a part there, so that each part gets its share of the fire. Combustion, which is complete, takes place among the pieces, and furnishes the heat for burning the material. The length of the firing zone in these kilns

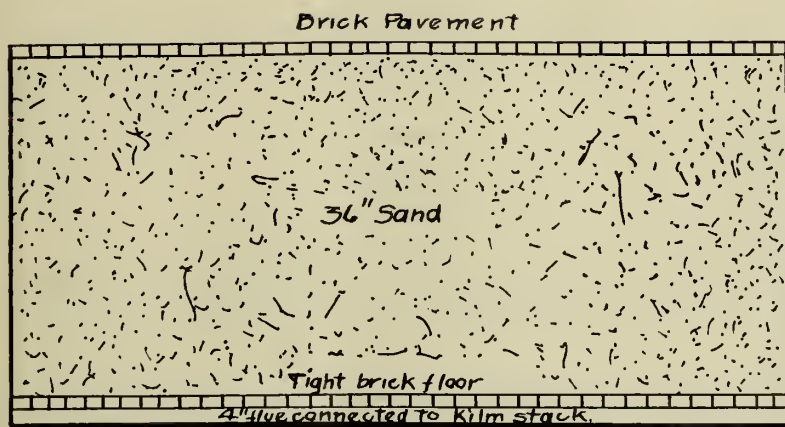
varies from 25 to 40 feet in different size kilns. This firing zone is constantly advancing, and leaves ware behind which is red hot. It is easily seen that the conditions for ideal combustion are here obtained mainly because of the high temperature of the entering air. So great is the economy of this kiln that only 30% of the fuel ordinarily used in a good down-draft kiln, is used for burning the same unit of ware in this kiln. The saving is attributed to four causes. 1. The air in the down-draft kiln is heated from 100°F. to 2000°F. while the temperature of the air for combustion in the continuous kiln is only raised about 100°F. in all. 2. The combustion is complete. 3. There is little radiation. 4. The ware in advance of the firing zone is heated to a high temperature by the gases from the hottest zone passing through the ware, and is heated to about 300°F. before passing out through the stack flue. The gases coming through the ware from the firing zone are not hot enough at first to burn the paper partition, but as the ware becomes dryer, the partition takes fire and the water smoking advances by one days setting. In some Hoffman kilns the partition is of sheet steel, and is so arranged that it can be drawn up, and out through small narrow openings in the covering arch.

Kilns of this type have been changed from the continuous tunnel to two parallel tunnels connected at each end by flues, which keep the gases going around and advancing the heat all the time. Such kilns have a rectangular ground plan, and take up slightly less room than the flattened ring type, and,

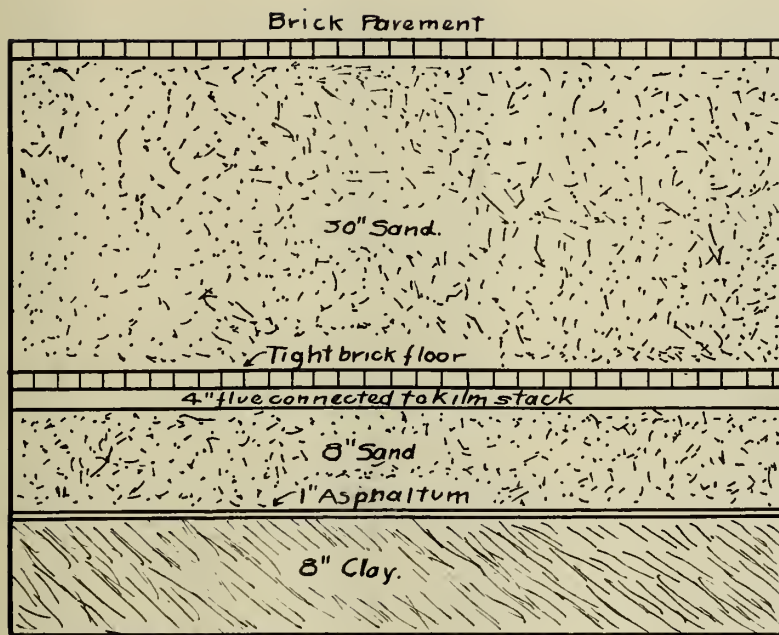
besides, can be used to a far greater advantage where any system of car transfers is used for bringing in the dried ware.

The floors of such kilns are of solid construction, and have no flues whatsoever below the floor level for the escape of gases with the possible exception of the main stack flue. A cross-section of the German type of floor is shown in figure 38. The English method of insulating the burning ware is shown in a similar sketch. (figure 39). Notice will be taken of the care with which the moisture from the ground is kept out.

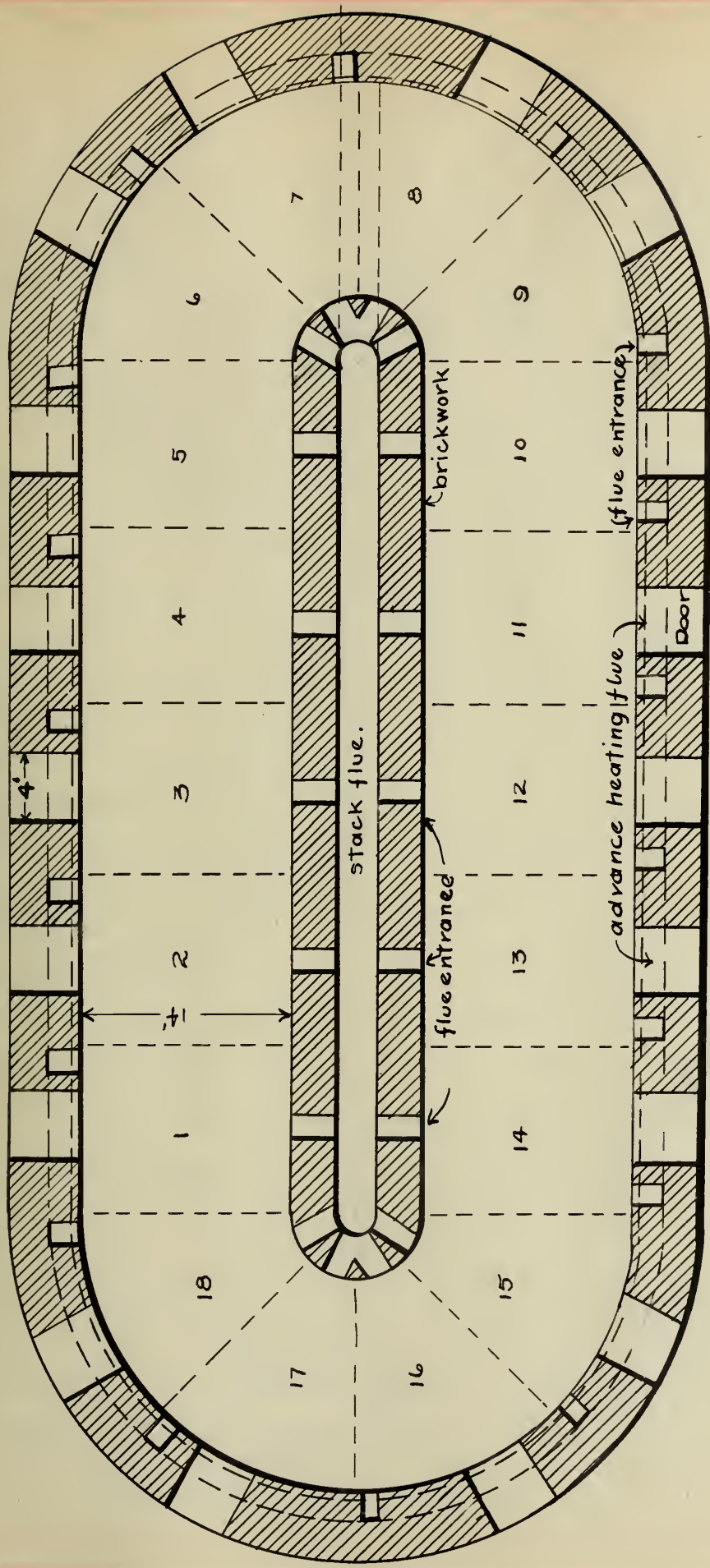
In most kilns of this type some advance system of heating is used. Figure 40 shows the flues in the outer wall through which heat from behind the burning zone may be taken, and conducted to the chambers or settings in which the paper partitions have not yet burned out. This method of removing a part of the moisture from the coolest ware is taken, because, if the gases from the firing zone were used, the moisture collected by them from the wares which are almost red hot, moisture (chemical moisture) will be deposited in the form of dew upon the coldest ware. Ware which dries out very rapidly need not have this auxiliary heating system in the kiln, because the firing zone may be advanced more rapidly with the result that the heating zone in front of the fires will not be so long and the gases will go to the stack at a higher temperature. If the temperature is above a certain point, which differs with every clay the dew, which is deposited will be removed so quickly that the surface of the ware will not be damaged. Some factor-



Section of German Continuous Kiln Floor.
Fig. 38.



Section of English Continuous Kilm Floor.
Fig.39.

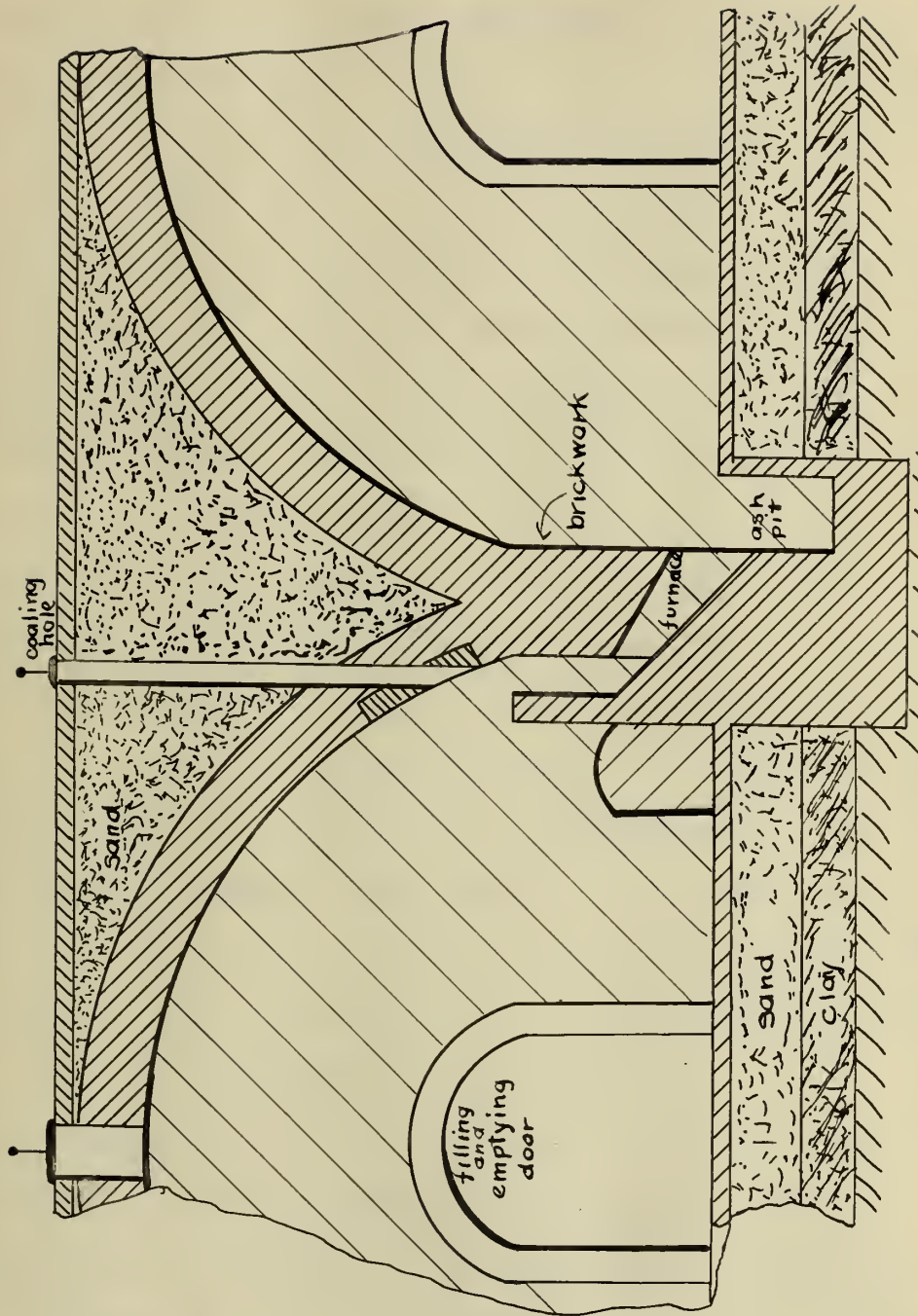


Plan of 18 chamber Hoffman Continuous Kiln taken at the floor level.
Fig. 40.



ies are bothered greatly by the dew formed upon the surface dissolving the soluble salts while the moisture is yet in the ware, and bringing them to the surfaces. When the dew is evaporated these salts are left upon the surface, and when burned give a white-washed appearance. This same trouble is experienced in dryers to a somewhat less extent. The only remedies used effectively are: 1. Drying the ware faster, 2. Adding carbonate of brytes, which changes the salts to an insoluble form, is given an intimate mixture with them as in the pug mill where water is present. The second method does not work satisfactorily in the dry press process because of the lack of water in which the brytes may dissolve. Very little trouble is experienced in the other types of kilns with the exception of the semi-continuous type in which it is the same as in the continuous.

Another modification of the Hoffman kiln, which has been designed to overcome the burning of the fuel with the ware is the Ehricht kiln. This is a side fired kiln in which the coal is allowed to roll down on temporary steps set between settings where the designer of the kiln uses a tunnel kiln, or where a series of compartments as in figure 41 are used the steps are made permanent and a bag wall is used on one side to prevent the coal from getting in among the wares. The coal as it rolls down these steps shown in figure 41 is completely burned under as favorable conditions as in the original kiln with the result of a cleaner ware more agreeable to handle in emptying the kiln. The ashes which are slowly worked down into the pit for them are removed through doors opening upon the

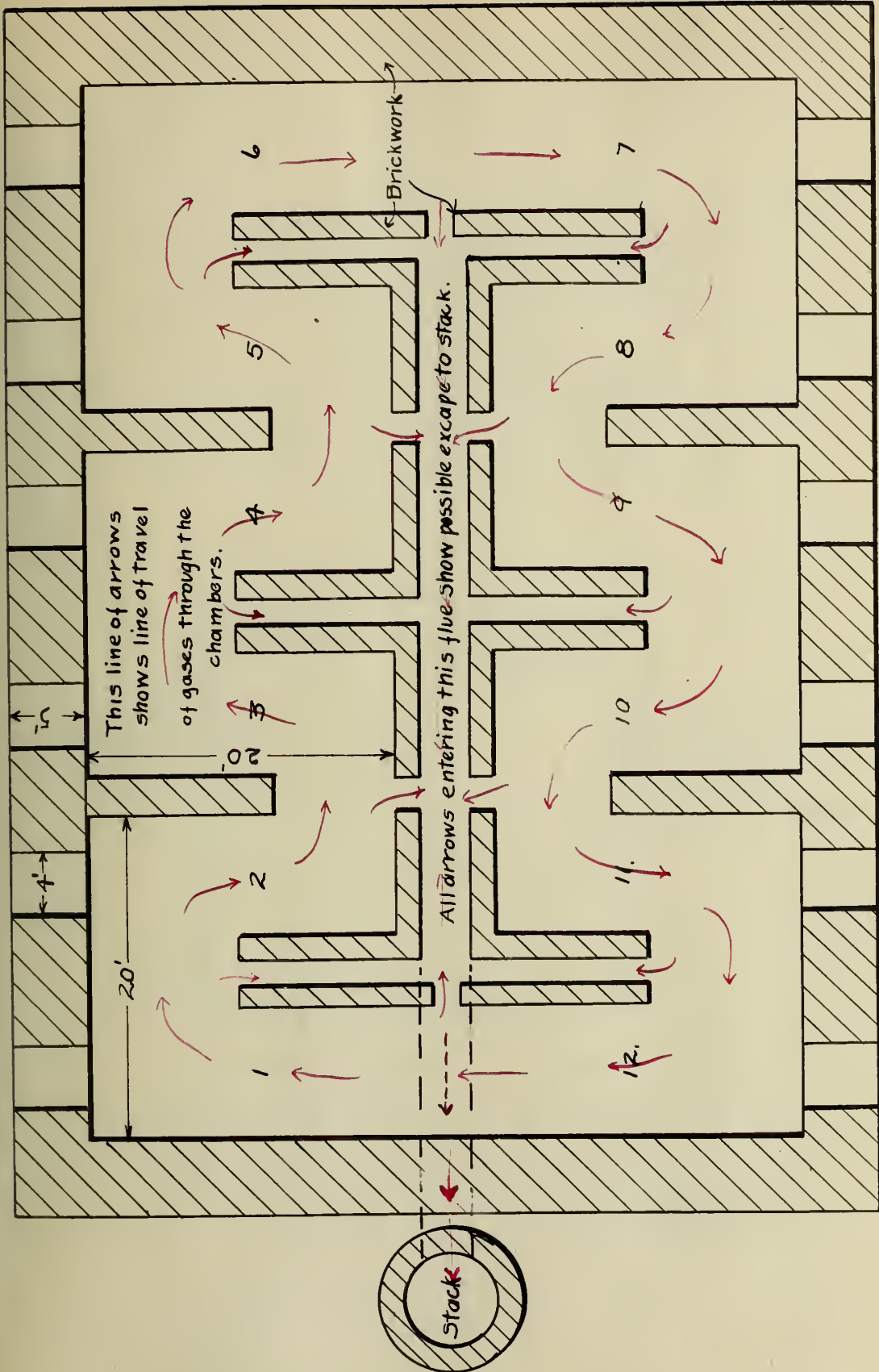


Section of two Chambers of Ehricht Continuous Kiln Fig. 41.

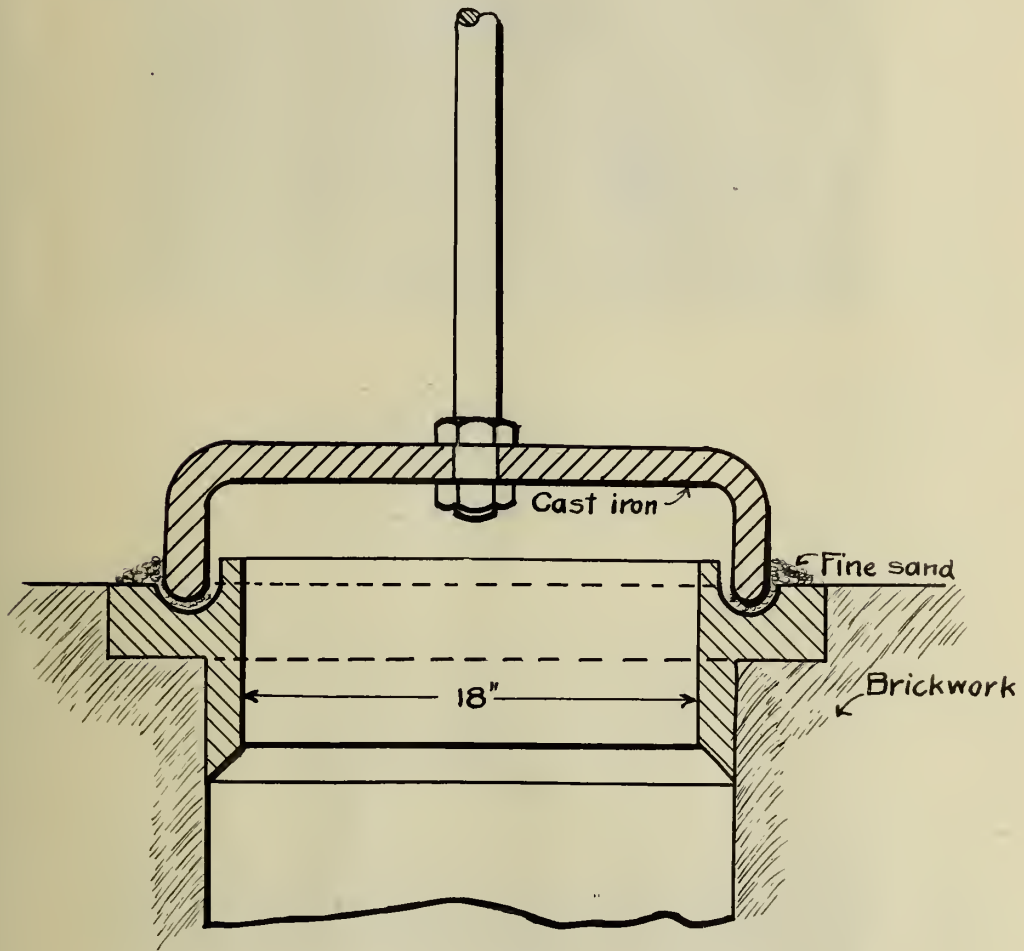
yard. The figure shows the compartments continuous kiln which is not of Hoffman invention. The first application was, however, made on one of Hoffman's kilns. The advance heating and stack flues are the same in general design as those shown in figure 40 of the Hoffman kiln.

The Buehrer modification of the Hoffman kiln is shown in figure 42. The idea in mind in designing this kiln was to have the gases travel a long distance before going out of the chambers into the stack. The entrance to the stack flue shown centrally in the figure are closed or opened at will from above by use of the bell damper shown in figure 43, which is used in all continuous kilns because of its self adjusting air tight properties. The Buehrer kiln is called the zig-zag kiln by the Germans. Such a kiln is very expensive to construct because of the heavy construction necessary to hold the heavy crowns of irregular shape together. The thrust on the outer walls is taken care of by sloping the outer wall enough so that the line of thrust comes within the foundation. In this method of construction no bands or extra bracing is required.

The latest, and by far the most convenient form of continuous kiln, has been designed, and constructed by P. S. Youngren of Milwaukee Wisconsin. This kiln uses producer gas as a fuel. The gas was first supplied by individual producers for each compartment, but, after a few years experience, it was found that the constant heating up, and cooling off of these producers wasted fuel, and was hard upon the producers them-



Buehrer Continuous Kilm.
Fig. 42.



Continuous Kiln Damper.
Fig 43.

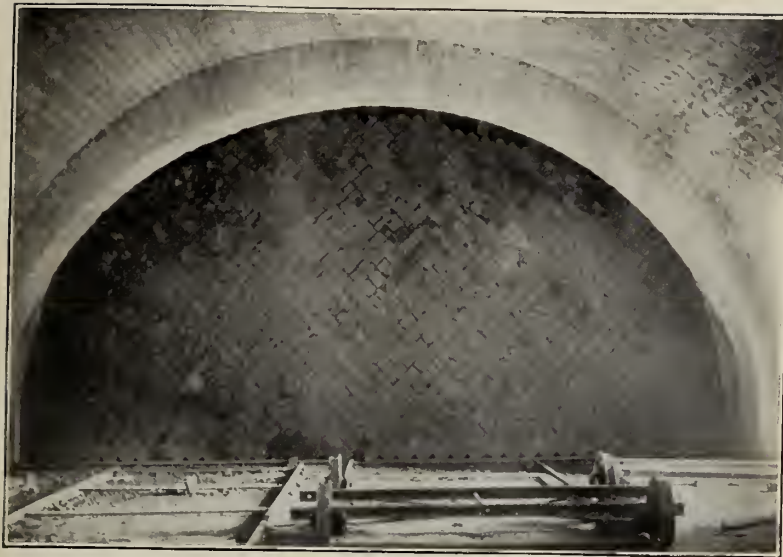


Fig. 2. Interior View in Tunnel Kiln, showing Method of Piling Brick in Baffle Wall V.

Fig. 44.



Fig. 18. Continuous Tunnel Kiln in Course of Construction.

Fig. 45.

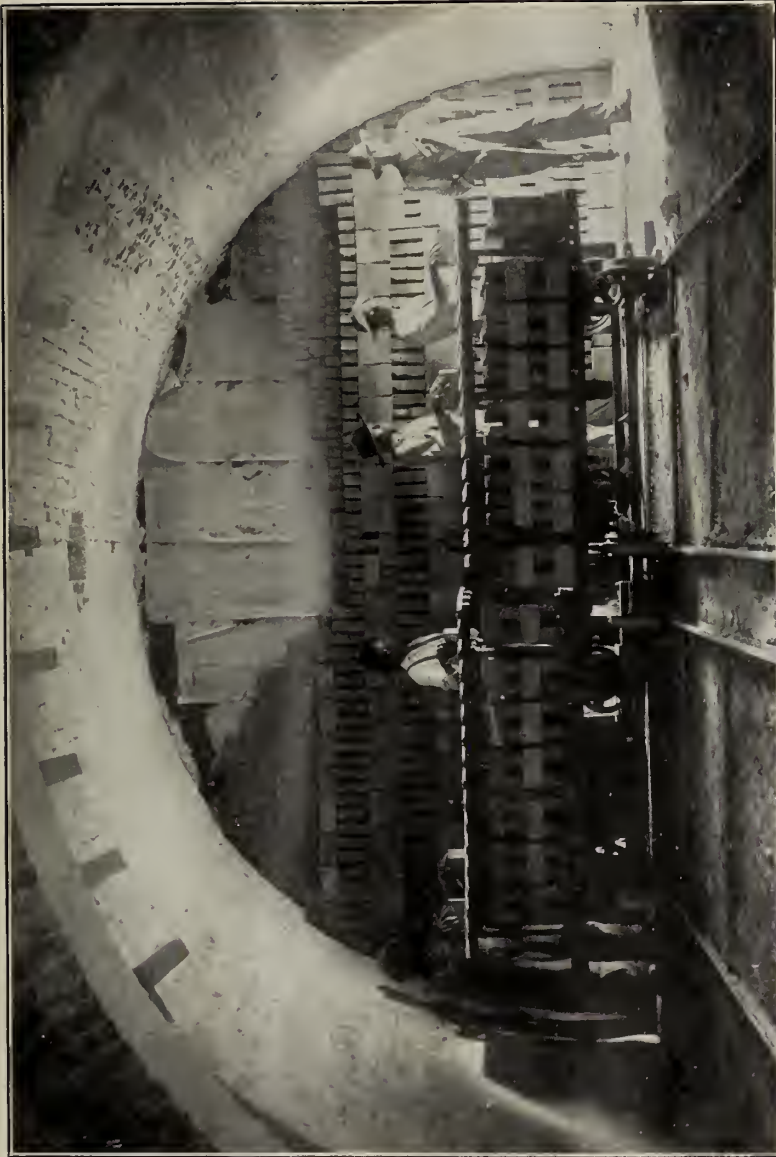


Fig. 2. Setting Brick in the Youngren Continuous Tunnel Kiln.

Fig.48.

selves. The latest types use a battery of producers at the end of the kiln now in place of the individual producer. The kiln is now built in three forms, 1. The continuous tunnel kiln. 2. The compartment continuous kiln. 3. The compartment semi-continuous kiln.

The continuous tunnel kiln is of similar design to that of Hoffman's. The general plan is shown in figure 45. In this type the gas from the producers is lead through the flue a marked in figure 47 and distributed by the gas spreaders shown in figure 47 and the lateral gas inlets shown in figure 46. The partitions in this kiln are not air tight but are run high enough so that the gas which is to go up the stack is turned aside by the combined action of the permanent baffle in the arch, and the temporary partition (figure 44) piled between settings. Figure 48 shows the paper partition used in water-smoking. The outlets from the chambers are shown in figures 46 and 47 at b. The familiar bell control damper is shown at c with the main draft flue leading to the stack at d. The producer used may be of any type but the up-draft producer is probably the best for the purpose, because of the lower exit temperature of the gas from the producer. Where the temperature of the gas is high, quite a loss due to radiation from the gas flue will result with the accompanying deposition of tar and other hydrocarbons. This diposition does take place when the up draft type of producer is used, but there is no great loss of heat due to radiation. In most of the latest designs of these kilns, the gas may be lead through either of two ducts

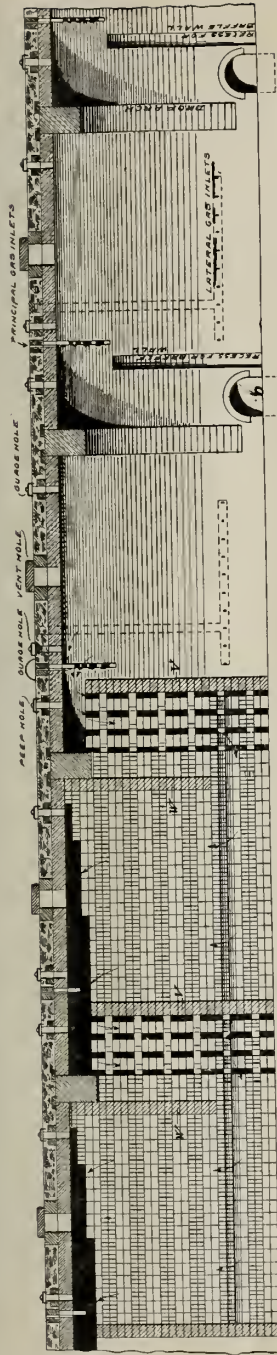


Fig. 46. Longitudinal Section of Tunnel Kilm.

Fig. 46.

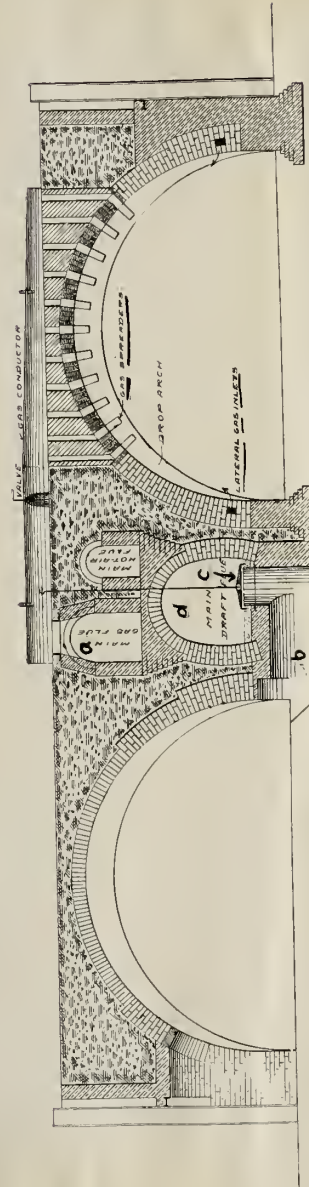


Fig. 47. Transverse Section of Tunnel Kilm.

Fig. 47.

so that one may be burned free of the tar, while the other is in use, and, therefore, obviating a shut down of the kiln for a few hours each week for the cleaning of the gas flue.

The compartment continuous kiln is shown in figure 49, which gives a floor plan of the compartments. Figure 50 shows a kiln in process of erection. The construction of this kiln is shown in figure 51 in which are shown all details. The path of the gas as it leaves the producers is through flue S figure 53 from where it goes into the goose neck shown above this flue over into the gas distributing flue K as shown in the same figure by arrows. The gas is then drawn downward through the small flues J controlled by N. As the gas reaches the bottom, it is mixed with the highly preheated gases from the red hot cooling chamber which has just been burned or from a chamber which is yet under fire. The gas is ignited at this point shown at Y of figure 51 after which it travels up and out of the flash wall into the chamber. The air, which was furnished to the fuel, comes from several chambers back of the fire from the cooler ware to the red hot as in all continuous kilns. The gases from the flash wall passes upward to the arch, and then down through the ware, and through the floor. The cross ducts in the floor shown in figure 51 conduct this gas through several chambers as shown in figure 54 until it becomes so cool that no further use can be made of it without it depositing its moisture upon the cold ware. It is then taken up the stack through the large flue running throughout the length of the chamber shown at B in figure 55. In figure 54 we have the meth-

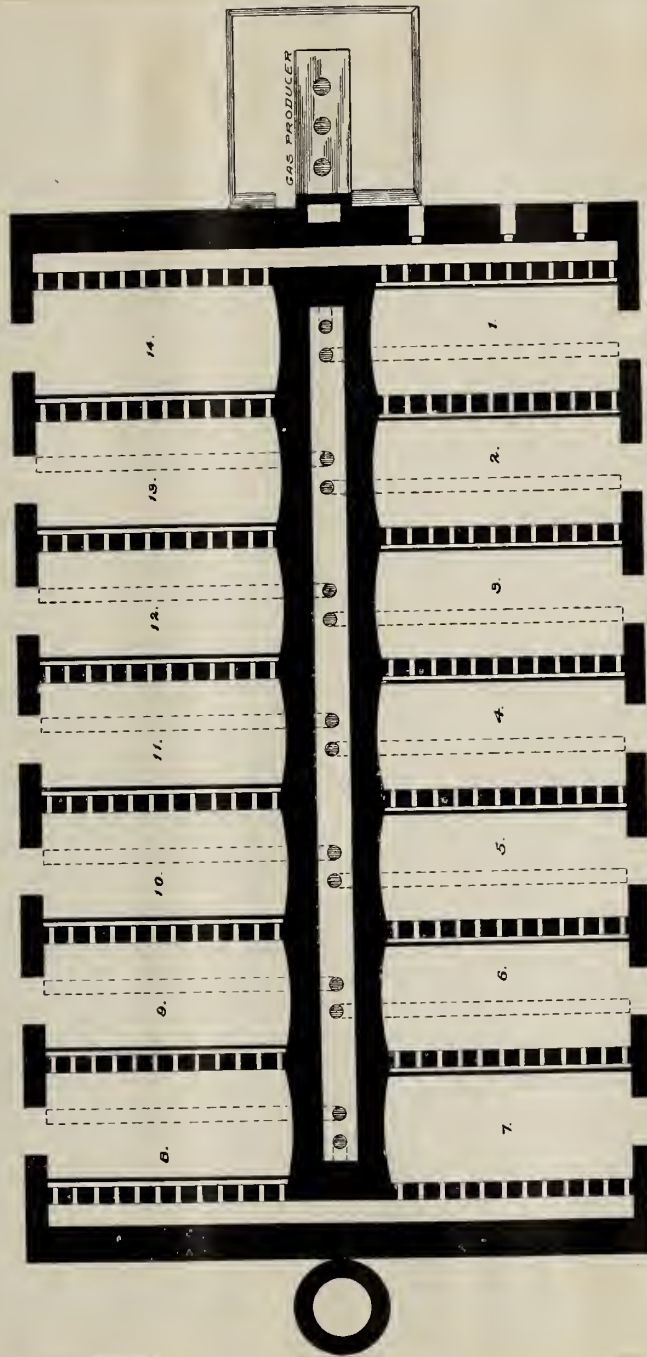


Fig. 1. General Ground Plan of the Youngren Continuous Compartment Kiln.

Fig. 49.



Fig. 3 Compartment Kiln in Course of Erection.

Fig. 50.

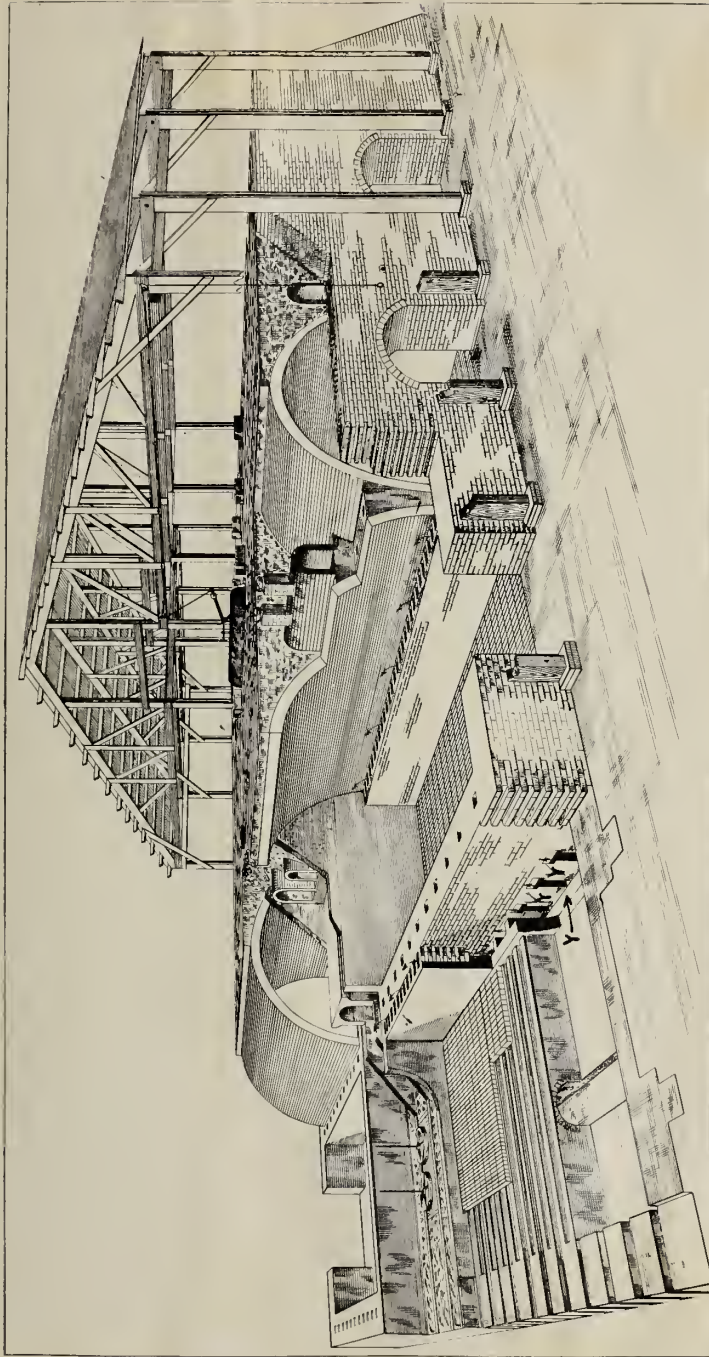


Fig. 1. Sectional Perspective of the Youngren Continuous Compartment Kiln.

Fig.51.

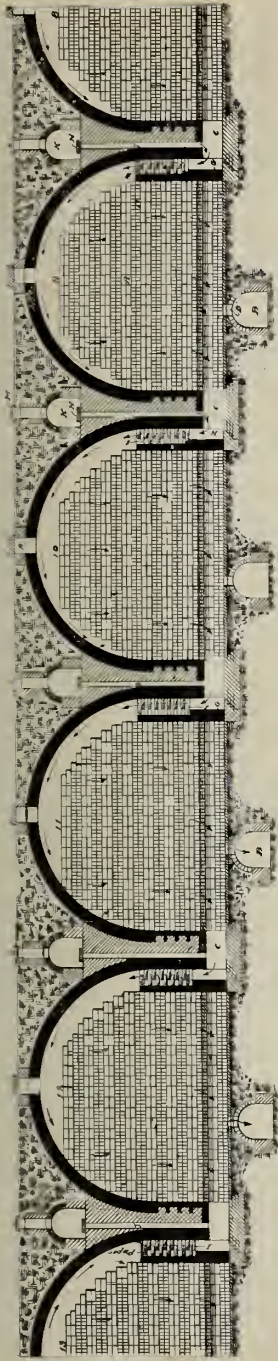


Fig. 52. Transverse Section of Compartments.

Fig. 52.

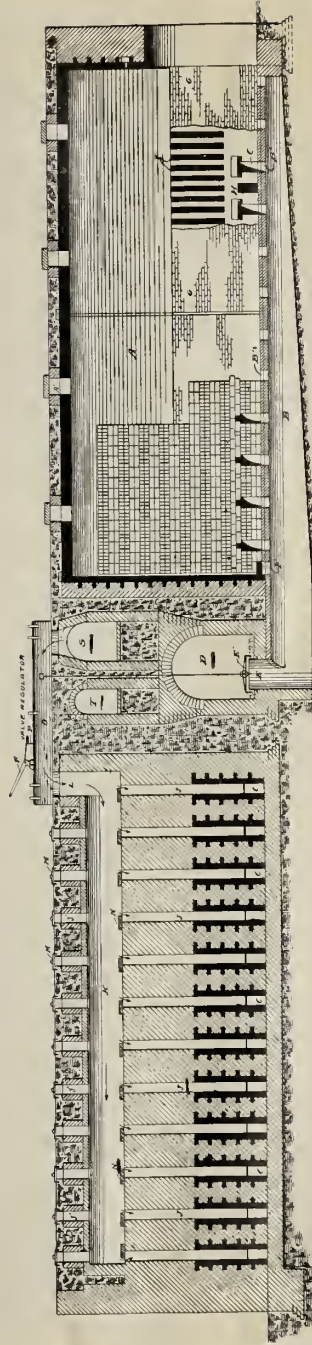


Fig. 53. Longitudinal Section through Gas Distributing Flue and through Center of Compartment.

Fig 53.

od of distributing the hot gases where advanced heating is used. Figure 55 shows details of construction not so clearly shown in other figures. In figure 56 is shown the appearance of the kiln ready for work. Although part of the fuel is lost in the tar deposits, the loss is more than balanced by saving in coal handling, which is all delivered at one point for the entire kiln. The open top continuous kiln as shown in figure 57 is sunken so that the top is on a level with the ground. The crown or cover consists of a temporary platting of large fire clay blocks which are plastered with a non-shrinking clay so that a reasonably tight cover is insured. The flue systems are the same in this kiln as in the continuous tunnel Hoffman as are also the floors. These kilns are also very economical in the use of fuel.

4. THE SEMI-CONTINUOUS KILN.

The semi-continuous kiln is the same in general principle as the continuous with all the modifications and improvements equally adaptable. It is not quite so saving with fuel as the simple continuous, but has important advantages in emptying and filling. It consists of a single row of compartments, or a single tunnel with doors on each side leading into the same chamber. The first compartment, or first section of the tunnel, is fired by means of the ordinary horizontal grate furnace as used in the down-draft kiln. After the burning is well advanced in chamber number one, the heat is avail-

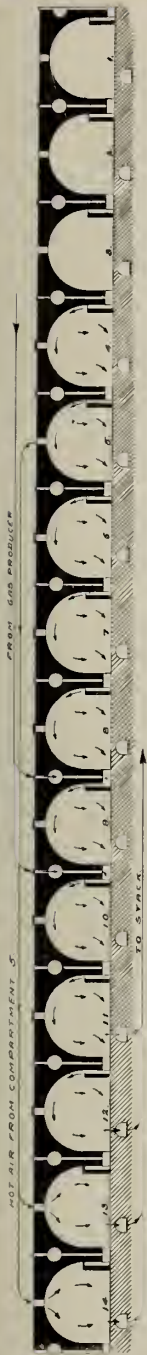


Fig. 54. Diagram showing "Modus Operandi" of Compartment Kiln.

Fig. 54.

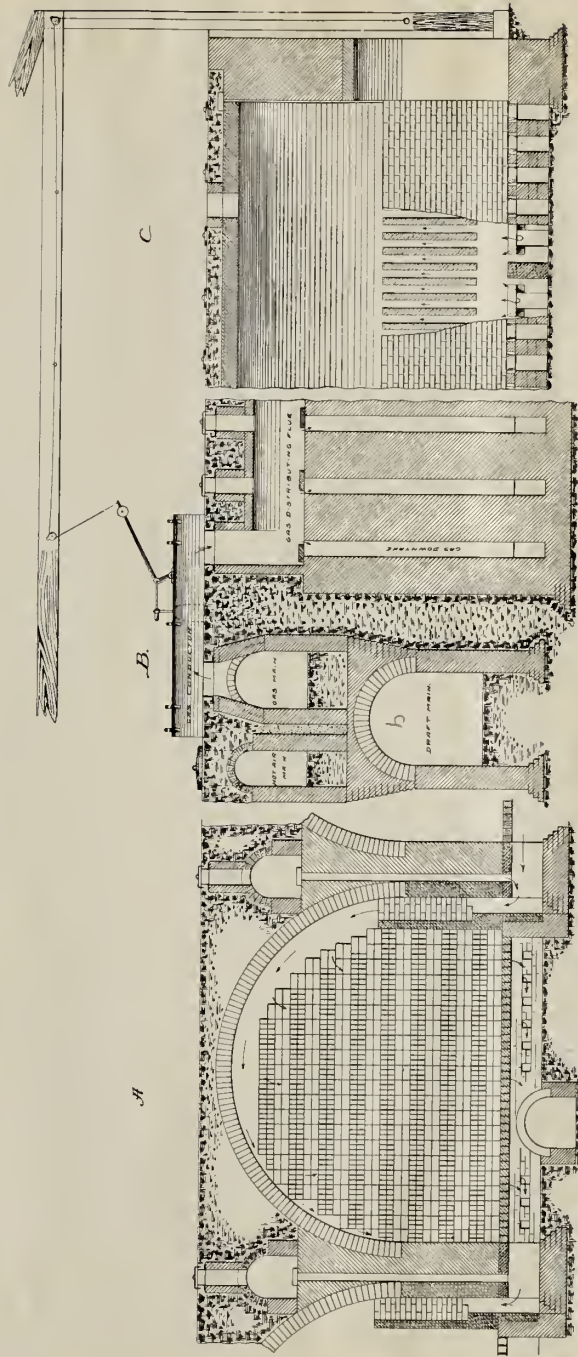
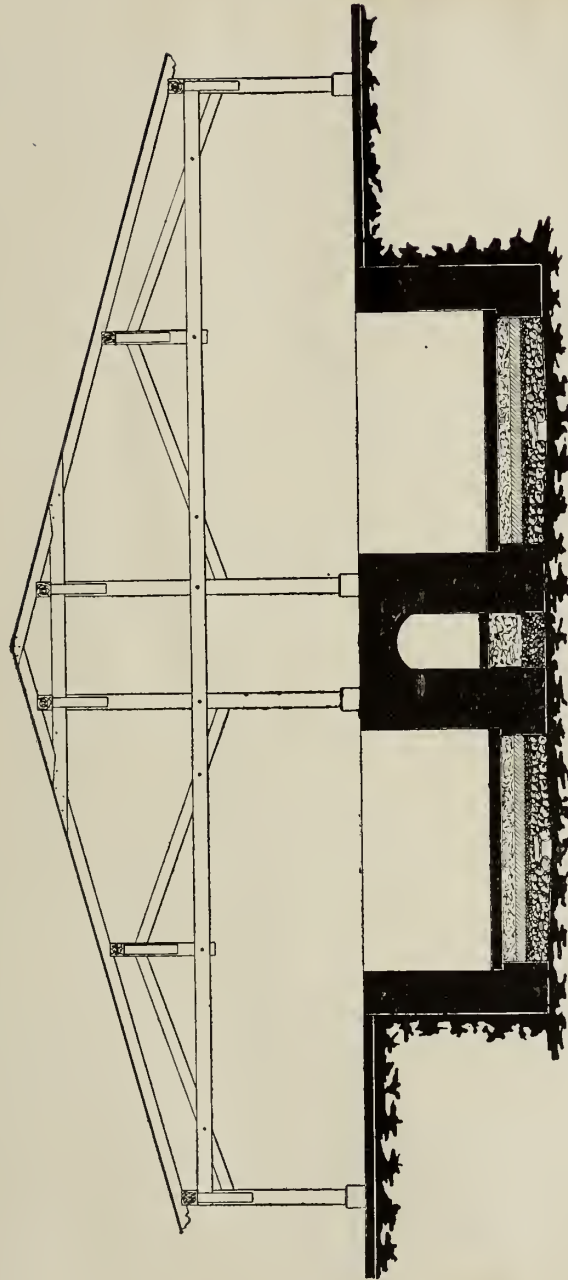


Fig. 55. Sectional View of the Compartment Kiln, showing Gas Valve Adjustment and Screen over Combustion Chambers.

Fig. 55.



A Complete Youngren Kiln.
Fig. 56.

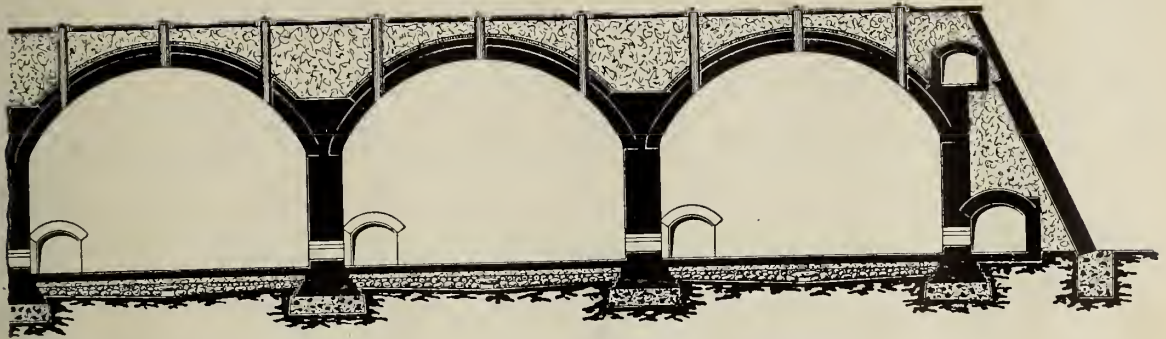


THE RICHARDSON-LOVEJOY OPEN-TOP CONTINUOUS KILN.
KILN NO 34

20

Fig. 57.





THE RICHARDSON-LOVEJOY CHAMBERED CONTINUOUS KILN
KILN NO. 36

28

Fig. 58.



THE RICHADSON-LOVEJOY ANNULAR KILN WITHOUT UNDERGROUND FLUES.
KILN NO. 35

Fig. 59.

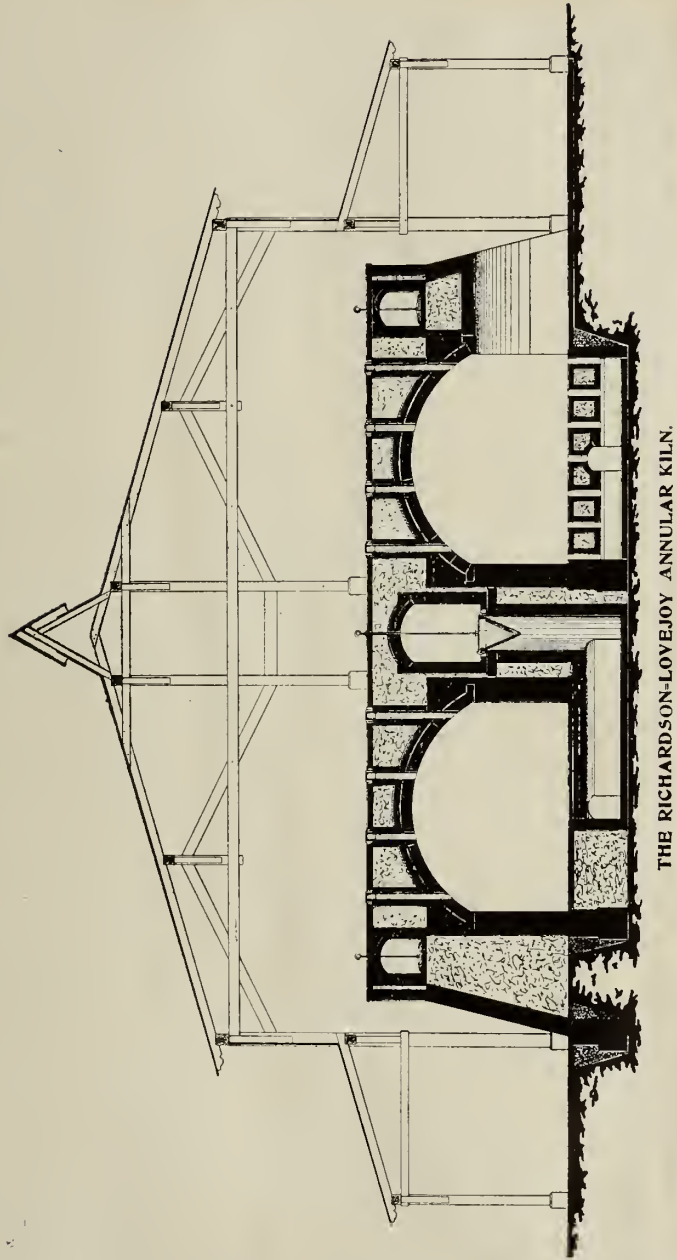
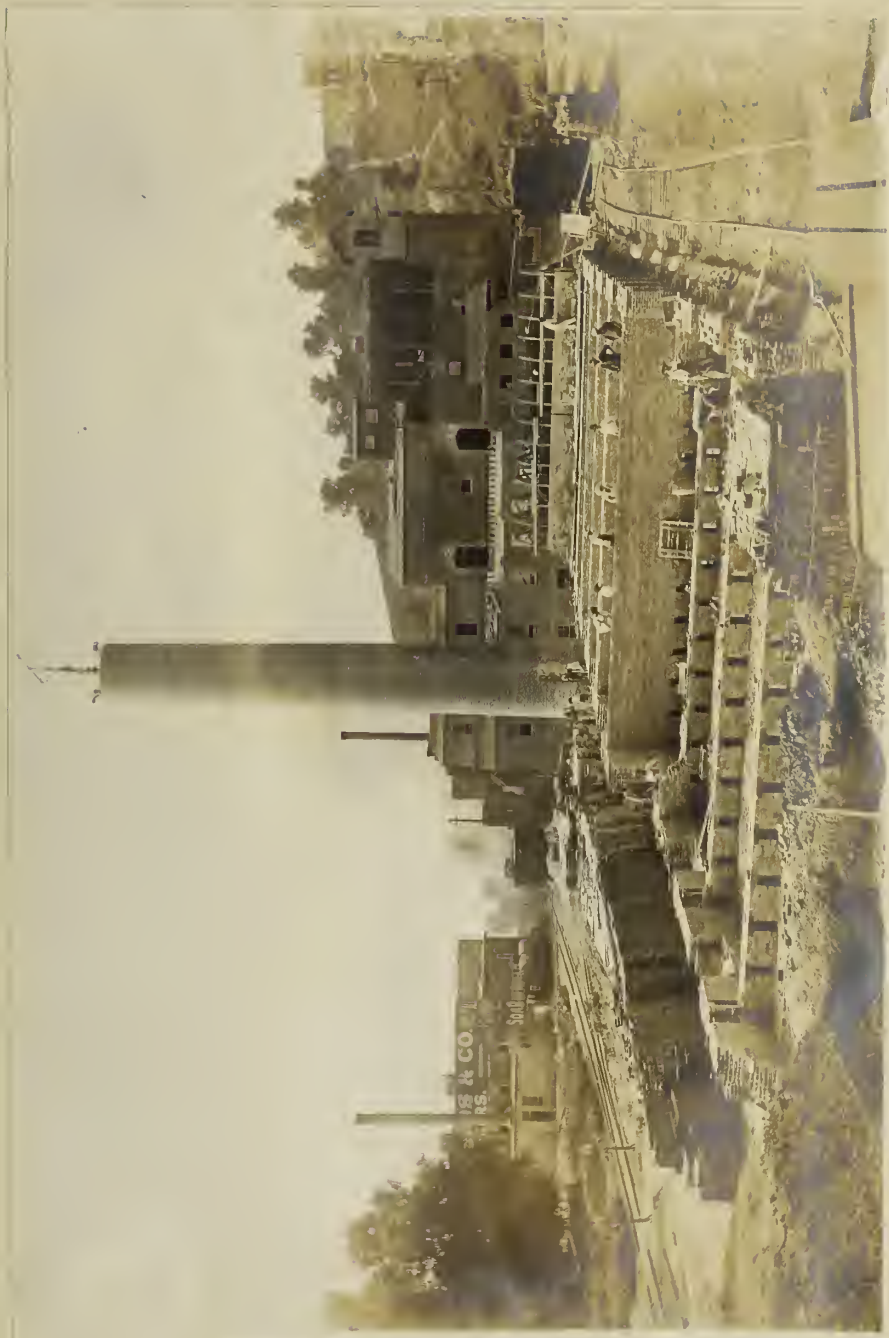


Fig. 60.



Youngren Semi-Continuous Kiln in Course of Erection Fig. 61.

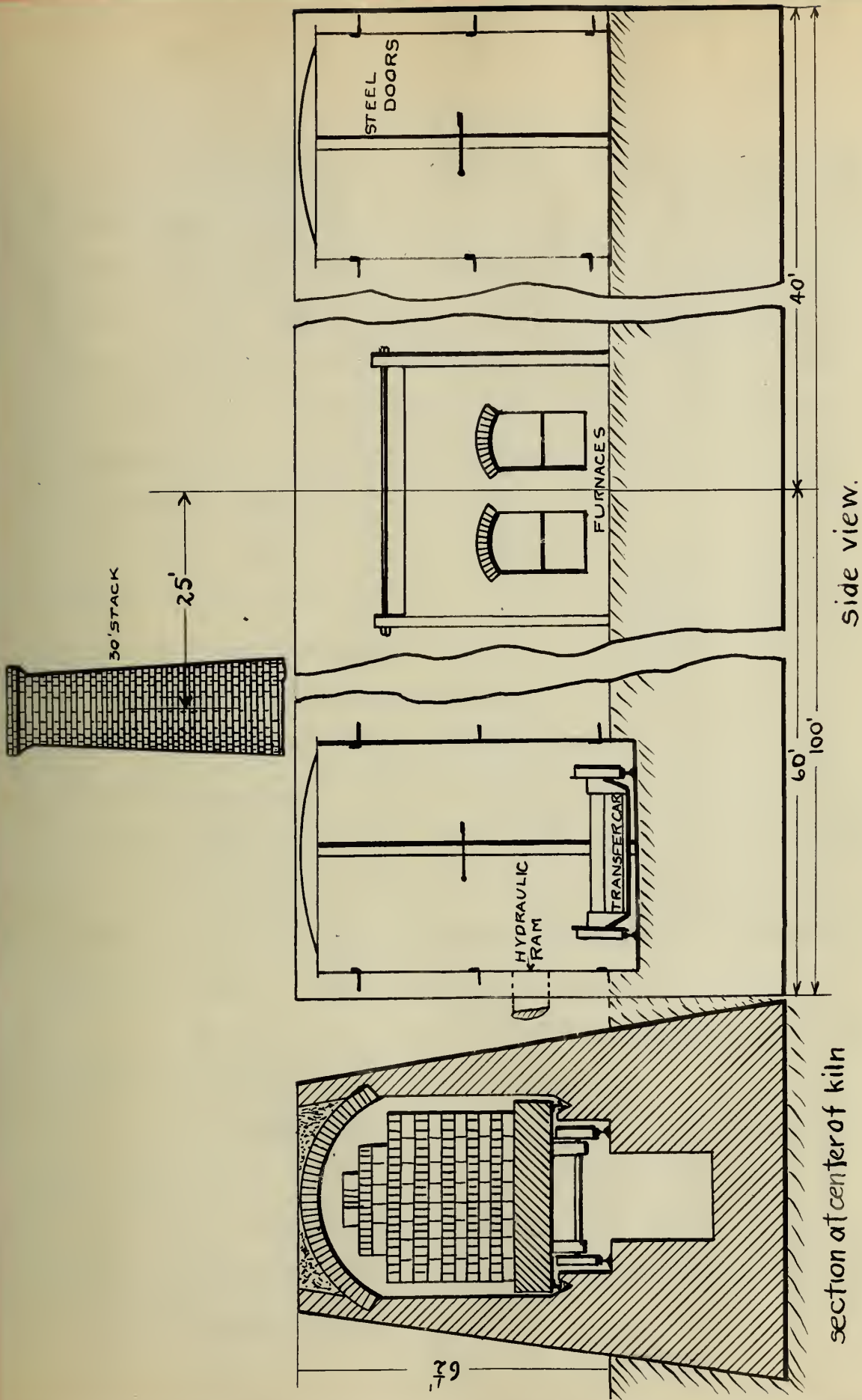
able for furnishing heated air to the following chambers. Nearly 60% more fuel is required in this first chamber than in the others, which have the same economy as the full continuous.

When this 60% increase of fuel required in the first chamber is divided among 12 to 14 chambers the loss is seen to be quite small, and when compared with the added economy of labor is hardly to be considered. This economy of labor comes in in emptying and filling, because the chambers can be filled from one side and emptied from the other. The workmen do not interfere with each other in this way, and the transfer dryer car tracks can be placed on one side with the sunken railway track for loading cars on the other. The chambers are also kept cooler by having two doors. P. S. Youngren has applied producer gas to a compartment kiln of this type, and, by conducting the heat from the last cooling chambers back to the starting chamber for preheating the air of combustion furnished to the gas to be burned, he has been able to bring the loss down to about 3% of the fuel used under the same condition in a full continuous kiln. Figure 61 shows a kiln of the type just mentioned in process of construction.

5. THE TUNNEL KILN.

Another departure from ordinary continuous kiln practice is to be found in the stationary fire and moving ware tunnel kiln. In this kiln, the ware is placed upon cars with heavy fire clay platforms of about 1 foot in thickness. The car is transferred into the lower end of a long fire brick tunnel generally over 100 feet in length, and is advanced, together

with all the cars in the tunnel, toward the opposite end by a hydraulic ram. The motion imparted is very slow, and is constant except when another car is added. The velocity of the cars is generally not over 5 feet an hour. The ware is first watersmoked by the gases coming from the hotter parts of the kiln, and is slowly heated, and oxidized until it reaches the hot or burning zone where the gases of combustion bath the wares as they advance. The ware travels about 30 feet in passing through this zone. The heat is furnished by a furnace to one side of the tunnel, or by producer gas, which burns among the ware. The air entering the end, at which the ware is taken out, is heated the same as in the ordinary continuous by the cooling ware. This heated air which is mixed with the producer gas or gases from the furnace produces complete combustion. The Germans call such a furnace a half-gas producer because partial combustion takes place in the furnace itself. The gases are kept from going underneath the kiln cars by means of angle irons shown at a in figure 62. These irons run in a trough of sand. The construction of the kiln must be of the very best material for one part is always hot and therefore cannot be repaired without closing down the kiln for several days. These kilns have been used in Germany and France for bisquetting the finer wares, and burning some of the finer grades of face brick, but, due to failure because of poor construction in this country, they have not been used at all. However, they are sure to be used sooner or latter because of their economy of fuel and labor.



Tunnel Kiln.
Fig. 62.

KILN STACKS.

The question of kiln stack is one which effects all of the above described kilns to the same extent, and may well be taken up as a whole. Of course no stack in the up-draft system is used because of the draft from the passage of the gas up through the wares being sufficient. In the down-draft kiln, the stacks are sometimes made to serve for several kilns to each stack. In this case, a diagonal partition is run up a part of the height of the stack so that the draft of one kiln on full fire does not effect the draft of another watersmoking. Because of the radiation from a single wall, stacks are built of two entirely independent walls. These walls have a dead air space between through which the heat does not readily pass. The top of the kiln stack should be capped with a heavy metal, or stone piece shaped so the wind in striking the side will be deflected upward and aid in the draft in place of dampering it as in the case when it blows at all strongly. A sketch of this is shown in figure 34 with arrows showing the probable path of travel of the air, and the escaping gases.

In calculating the height and diameter of a stack the things to be taken into consideration are:

1. How much coal per hour is to be burned, also how much per second?

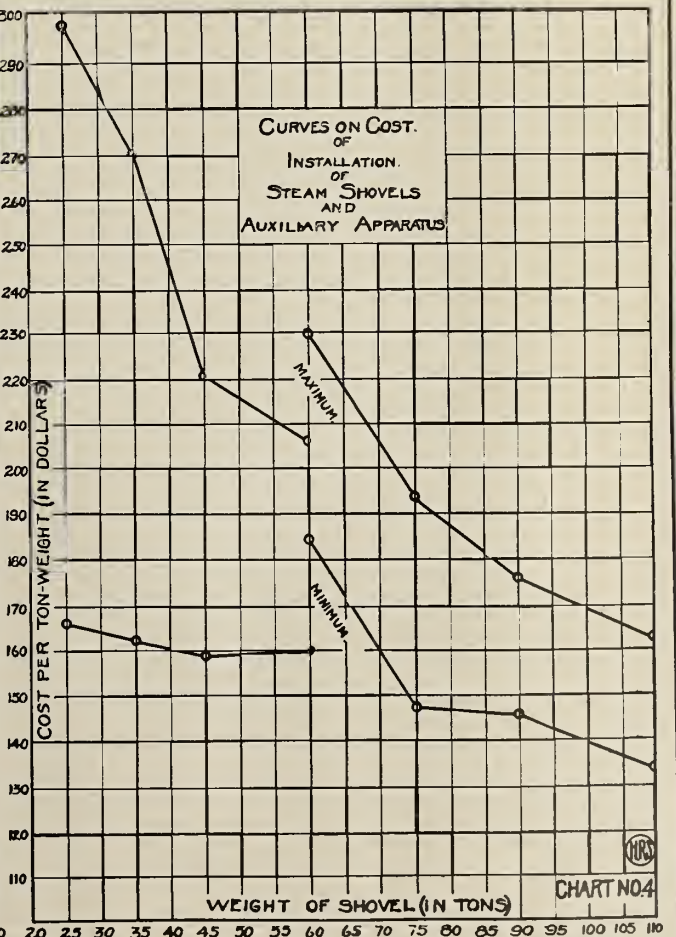
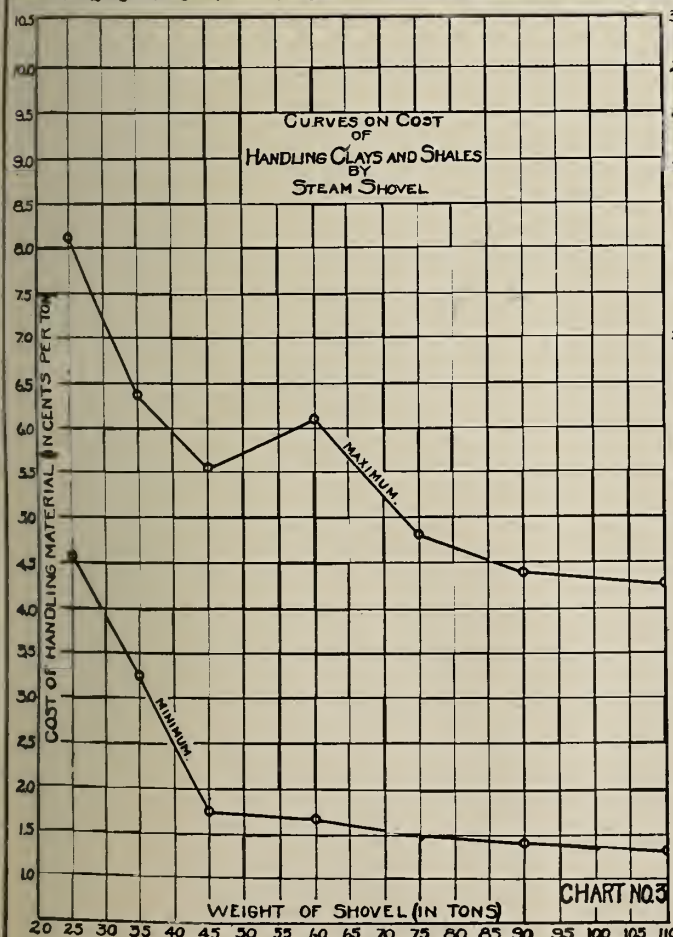
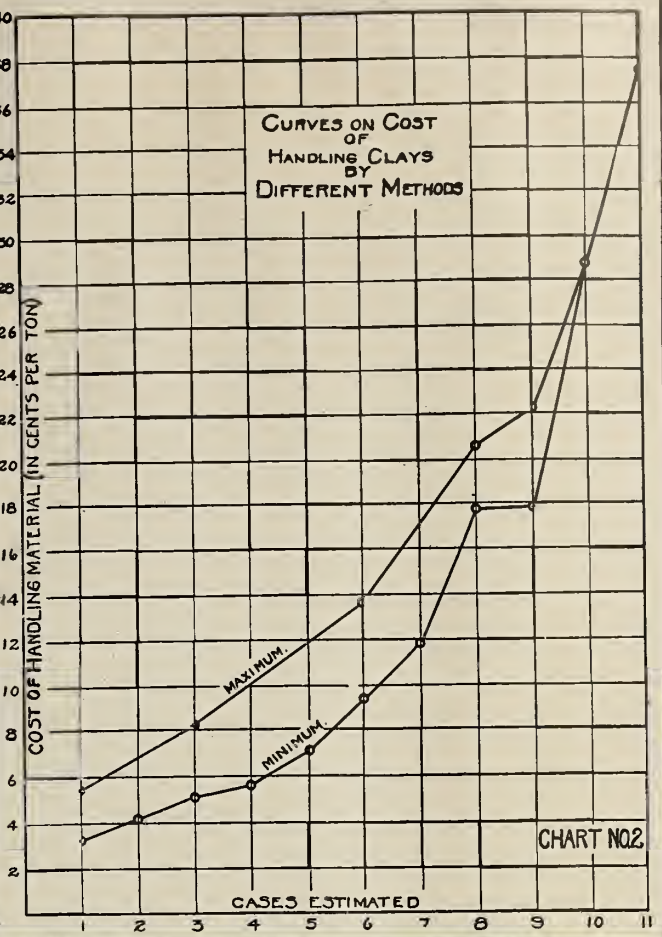
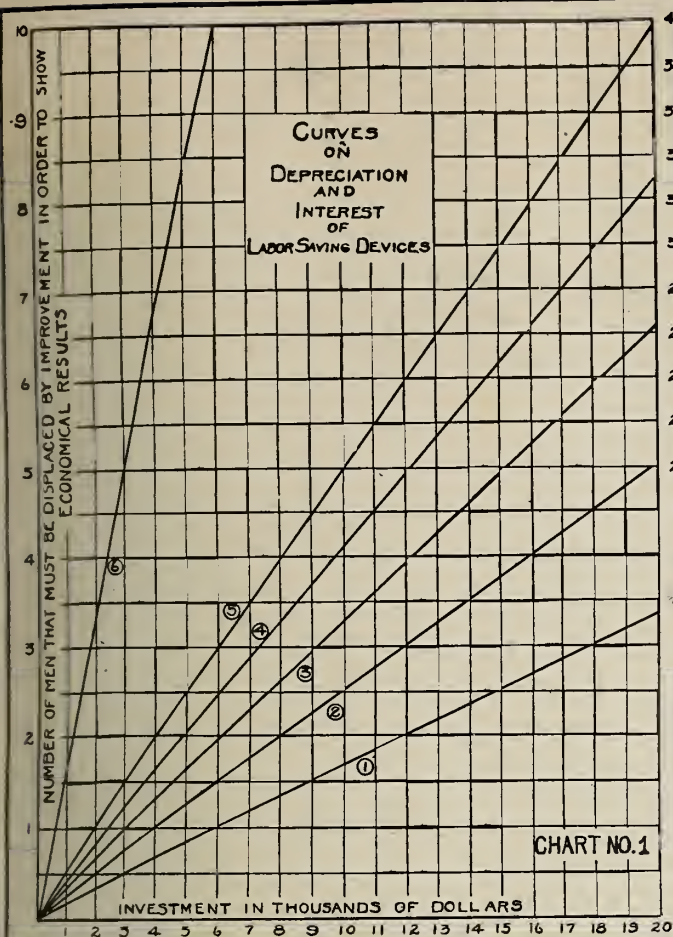
2. How many pounds of air per pound of coal is required for perfect combustion? This is generally multiplied by two for good results.

3. What is the draft to be assumed.

From the assumed draft calculate the required velocity of gases in feet per second. Knowing the temperature inside and outside of the stack calculate the height of stack to give the required difference in pressure and the draft. Knowing their velocity calculate the cross-sectional area of the stack.

VII. EXCAVATION AND TRANSPORTATION OF MATERIAL ABOUT FACTORY.

The means used in the excavation of the clay used by the clayworker differ very widely and are entirely dependant upon the quantity to be used and the compactness with which the clay lies in the bank. In shales the kind of material most generally used numerous difficulties are encountered because of their toughness and compactness in the bank. In some cases the steam shovel is used, while in others blasting must be done. The success of the steam shovel has been due to the small expense of handling after installation. The shovel not only loosening but also loading give all the advantages of a clay handling plant to be desired. The use of manual labor in loading after blasting makes this method expensive, and uncertain, for manual labor is certainly expensive at almost any cost. When clays are mined the best method is to blast the clay. The air drill is generally used to place the charge. The tables on the following page will show beyond a doubt why hand labor should be eliminated. The tables following shows the cost of handling by steam shovel in maximum and minimum conditions. The last printed table shows the cost of installation for various weights of steam shovels. These were gotten up by Mr. J. K. Moore and the author of this thesis for the Illinois Clayworker's Association which met in Champaign, January 22 to 24, 1907. The paper written by Mr. Moore and the author is also given before the tables.



Methods and Estimates of Cost of Handling Clay and Clay Materials.*

By Jos. K. Moore and H. R. Straight, University of Illinois, Urbana, Ill.

[Editorial Note. This part of the paper was presented by Jos. K. Moore, University of Illinois, Urbana, Ill.]

In the majority of cases the most simple means of handling clay and clay materials is the most effective.

Scrapers have been found to be both the simplest and cheapest means of excavating clay, but this is so only for small plants. In some cases it is absolutely necessary to resort to hand-digging, and when this is the case a greater facility in the work is obtained by watching closely the laborer. What is the difference between a poor and a good shoveler? Why is it one man is able to load faster than another? Is it indolence entirely?

The method of work has a great deal to do with it. Some men bend over and use their arms and shoulders in forcing the shovel into the soil. This is a waste of energy which is costing you dollars. Labor is the most expensive factor of production as expressed by curves to be shown later. The correct way to dig is to have the arms free to guide the shovel, and the force used to propel it downward should be the foot, and the handle should be as nearly perpendicular as possible. It is often well to put your good shovelers together and require that their pace be kept, or at least be a goal for which the others must strive. Walking on the ground tramps it, hence the cars and wagons should be brought as close as possible. Require the shovelers to keep the digging-floor level; an Irishman is the only laborer who will do this without being watched; as this aids when shifting the tram track it is necessary. The most economical number to shovel into a wagon is three or five, and when shoveling to a tram-car, two are used.

In large plants the steam-shovel is employed for excavating. The size of the shovel and its power is regulated by the capacity of the plant and the kind of material to be handled. Large steam-shovels of the 95-ton variety handle material at the rate of 200 tons per hour at their best. For some kind of work as low as 25-ton shovels are used. Where drainage is good and a sufficient water supply is at hand, stripping on a large scale may be carried on by hydraulic means. In this way, 1200 cu. yd. of boulder clay has been removed in 10 hours by two men using a ½-in. nozzle and 80-lb. pressure.

The material after being excavated must be carried to the plant for this purpose. The cable tramway has during the past few years come into very general use. This consists of a winding drum, cars and connecting cable. The winding drum generally is one of the paper-friction type, with a reduction of six or eight between the friction and cast-iron wheel against which it works, thus giving a good

arrangement, easily controlled, by which the load may be accelerated without extreme stresses in the belt or any of the parts of the drum. The cable required for such haulage may vary from ⅜ to ¾ in., depending upon the grade, number of cars and their capacity. They are made of six strands, seven wires to the strand, with hempen centers. The kind of cars used depends a great deal upon the method of loading. When this is to be done by hand, they should be designed as low as good practice would allow; while on the other hand if a steam-shovel is employed an advantage is gained by the use of a higher car, from the fact that the distance through which the shovel arm must travel is less. In loading from a bridge both kinds of cars are often seen. The cars used for steam-shovel loading is by necessity side or end-dump, because of the difficulty of making the mechanism of a bottom-dump car sufficiently strong to withstand the shock due to the quantity of the falling load from the dipper. The cars employed where hand-loading is resorted to should be side-dump also, as the men are required to elevate the material a shorter distance. End-dump cars are seldom used except when the construction of the plant demands it, and these are to be avoided if possible as they are very poorly balanced. The capacity of said cars vary from 1½ to 3 yd., depending upon the size of plant.

Where hauls are long three other methods are resorted to. These are the use of wagons, the dinkey locomotive, and the aerial tramway. The first are used in smaller plants where the cost of installation and operation of more elaborate methods can be ill afforded; the second is usually operated in conjunction with the tramway, thus increasing the capacity of the tracks; the third is used where the country is rough and grading expensive.

In the plant proper the conveying is best carried on by means of belt conveyors where the direction is horizontal, and cup elevators where the direction is vertical. However, we know of the successful elevation of material by means of smooth-belt conveyors at an angle of 25 deg.

The green and dry products are best handled on flat-belt conveyors, such as the Scott system or others. The practice of loading and unloading the kiln by means of conveyors is both practical and economical. Where the plant is compact the conveyor can carry the burned ware to their respective stacks, the sorting being done in transit. For handling finished products and distributing the brick from yard to car or wagon the Barney conveyor system is especially adapted. This consists of an endless chain along which are suspended hooks that hold five bricks each, and are built in such a form that the bricks are readily grasped by the unloader. If dry material is to be conveyed, for example, from bins where cars are dumped, to various bins connecting with the dry-pans, a

*Paper presented to the Illinois Clay Workers Association, at Champaign, Ill., Jan. 22-24, 1907.

belt conveyor can be used and the material taken from the belt at any point by a self-propelling tripper. This apparatus is manufactured by Stephens-Adamson Co., Aurora, Ill., and is especially suited to plants where the material is shipped in by railroad. Having discussed the methods in use let us now try to answer the question When does it pay to install labor-saving devices in handling clay and clay products?

The possibility of eliminating hand-labor increases proportionally with the capacity and output of a plant. In plants of small capacity for example, the winning of the clay is most economically accomplished in some instances by pick or shovel and wheelbarrows, and as the capacity increases the method of winning may pass in succession from the wheelbarrow, scraper, clay gatherer and finally to the steam-shovel. Local conditions such as quantity and character of stripping, vertical variation in the quality of the clay, kind and mode of occurrence of detrimental material, such as niggerheads, sulphur balls, the difference in level of factory and floor of clay pit, etc., influence greatly the adoption of methods of winning, whether the plant has large or small capacity; but the fact remains that the smaller the capacity of the plant, the more dependent must be the operators on hand-labor to gather and deliver clay to the machines. What is true in case of winning of clay is true throughout the whole process, even to loading the finished product.

Practically, the only considerations, aside from those of local conditions, that limit the use of labor-saving devices to the plants of comparatively large capacity are those of interest on capital invested in a particular device, its cost of maintenance, and amount of depreciation compared with the wages that would have to be paid for the execution of the same kind and amount of service. As a matter of fact, similar considerations affect the adoption of small as large kilns, steam heat driers as against waste-heat driers, installation of a car system as against the old-time track-and-barrow methods, etc.

After having given some time to the study of efficiency of clayworking machinery and appliances, both from practical observation in a large number of clayworking plants of varying capacities, and of published data concerning the cost of installation, repair and estimated depreciation and efficiency of similar devices in other industries, the writers have developed a scheme by which, it is believed, the question of economy effected by the installation of any labor-saving device can be readily determined.

We have based our calculation on the average working capacity and wages of the class of laborers that would be supplanted in each case. In this it is realized that we are using as a basis of our calculations a factor that varies greatly, according to the skill of the laborer and the ability of the foreman. The watching of the diggers, as we have before cited, is evidence of this.

These items concerning the relative efficiency of hand laborers have been a subject of study and calculation by railroad engineers. Having had opportunity to study the subject of pick-and-shovel laborers on railroad construction where every item affecting efficiency of hand labor is considered, we feel that we have used as a basis of calculation figures that represent the average wage and working capacity of a common laborer. Where more skilled labor is effected by the installation of mechanical devices, merely wages have been taken into consideration.

The estimate of cost for the installment of some of these different labor-saving devices, and of handling materials with the same, we have attempted to show by curves, which Mr. Straight will now explain, and should they prove as interesting to you as they have been instructive to us during their preparation, I am sure the time taken to prepare them shall have been well spent.

[Editorial Note. The explanation of the accompanying curve-sheets and tables of estimation was then effectively made by H. R. Straight, University of Illinois, Urbana, Ill.]

The following details show the conditions encountered in Curves 1 to 6 on Curve-Sheet No. 1.

Curve No. 1. (5% interest, 5% depreciation.)

Rails, spikes, flanges.

Engines.

Winding Drums.

Curve No. 2. (5% interest, 10% depreciation.)

Boilers.

Outside clay cars (no very heavy shocks).

Donkey locomotive and steam-shovel in clay.

Crushing machinery.

Ties.

Curve No. 3. (5% interest, 15% depreciation.)

Transmission belts (protected), also in No. 2 class.

Curve No. 4. (5% interest, 20% depreciation.)

Outside clay cars, heavy service.

Steam-shovels in shale.

Conveyor belts.

Kiln brick-conveyor.

Elevators.

Transmission belts (not protected).

Clay gatherers.

Curve No. 5. (5% interest, 25% depreciation.)

Plows and scrapers.

Curve No. 6. (5% interest, 100% depreciation.)

Cables.

EXAMPLE OF USE OF INVESTMENT CURVES.

(Sec Curve-Sheet No. 1.)

A man is using teams and wagons for hauling his clay from pit to crusher. He uses 200 tons per day, and it cost him the pay of the equivalent of 10 men, at \$2.00 to handle it.

He uses a steam-shovel at \$5,000 which, being included in curve No. 4, must displace one man.

He uses 1000 ft. of track at 50 cents per ft., which is fully covered by case in curve No. 2 and must displace 1/5 man.

He uses eight cars at \$150 as in curve No. 2 and must displace 3/10 man.

He uses 1000 ft. 1/2-in. cable at 7 1/2 cents as in curve No. 6 and must displace 5/10 man.

He uses a winding drum as in curve No. 1 at \$200 and it must displace 1/10 man.

He uses power to the approximate extent of 1/2 man's wages. (For winding drum.)

Total men to be displaced=3 (approx.).

Total men to run shovel and cars and other machines need not be over 5 with an average wage of \$2.00 for so small a shovel; therefore he has saved the wages of (10-3)=5=2 men.

Notes.—Man's labor is rated at \$2.00 in curve-sheet.

Working days of the year taken as 300.

Table showing approximate cost per ton of handling clays by different methods arranged in order of economy for medium-sized plants. (See Curve-Sheet No. 2.)

1. 35-ton steam-shovel handling clay.
Capacities, etc., as in table No. 2. Cost per ton—3.23 to 5.51 cents.
2. 1 team scraping into car bridge with wheel scraper in loose material. Team at \$3.50 per day.
Car man at \$2.00 per day.
Drum boy at \$1.50 per day.
Cost of 10 h. p. used in drum at \$35.00 per h. p. per year=\$1.16.
Capacity 200 tons per day. Cost per ton \$4.08. ϕ
3. 25-ton steam-shovel handling clay.
Capacities, etc., as in table No. 2. Cost per ton 4.54 to 8.14 cents.
4. 2 teams with slip scraper scraping into car bridge.
Teams at \$3.50 per day.
Car man at \$2.00 per day.
Drum boy at \$1.50 per day.
Capacity 200 tons. Cost per ton 5.83 cents.
Cost of h. p. used on drum same as above, \$1.16.
5. 1 team scraping into wagon loading inside bridge with wheel scraper.
2 teams hauling 1000 to 2000 ft. with wagon.
3 teams at \$3.50 per day.
1 bridge man at \$2.00 per day.
Plowing and bunching \$1.75.
Capacity 200 tons per day. Cost per ton 7.1 cents.
6. 25-ton shovel loading into wagons.
5 to 7 teams at \$3.50 per day.
Other expenses practically the same.
Capacity 225 tons. Cost per ton 9.6 to 13.75 cents.
7. 2 teams scraping into wagon-loading bridge with slip scrapers. 2 teams hauling.
1 bridge man at \$2.00.
1 slip man at \$2.00.
Plowing, \$1.75.
Capacity 200 tons. Cost per ton, 9.87 cents.
8. 5 men shoveling in plowed material.
3 to 4 teams at \$3.50 per day. Haul 1000 to 2000 ft.
5 men at \$2.00 per day.
Plowing, \$1.75.
Capacity 125 tons. Cost per ton, 17.8 to 20.6 cents.
9. 3 men shoveling in plowed material.
2 to 3 teams at \$3.50 per day. Haul 1000 to 2000 ft.
3 men at \$2.00 per day.
Plowing, \$1.75.
Capacity 80 tons. Cost per ton, 17.8 to 22.2 cents.
10. 4 men spading into 2 cars and picking material.
1 car man at \$2.00.
4 spaders at \$2.00.
Drum boy at \$1.50.
Capacity 40 tons. Cost per ton, 28.7 cents.
11. 4 men picking and loading into 2 wagons.
2 teams at \$3.50.
4 men at \$2.00.
Capacity 40 tons. Cost per ton, 37.5 cents.

Notes on above data.—Depreciation of wagons, cars cables and tracks not figured in the above. Slip scrapers, capacity estimated at 1/3 ton or 1/5 yd. Wheelers at twice capacity of slips.

COST OF HANDLING CLAY OR SOFT SHALE WITH A 25-TON STEAM-SHOVEL AND CABLE HAULAGE.

(Consult Curve-Sheet No. 3.)

ITEM.	Machines and Materials Used.	Per 10-hr. Day.	
		MIN.	MAX.
1	Interest on shovel. Investment \$3500 to \$5000	.46	.67
2	Cost of coal for shovel at \$1.40 per ton, 1/2 to 1 ton	.70	1.40
3	Oil, repairs, etc.....	.15	.30
4	Labor at \$2.00 per day, 4 to 6 men.....	8.00	12.00
5	Interest on 4 to 8 cars at \$125 each	.06	.12
6	Interest on track 800 to 2000 ft.	.04	.10
7	Depreciation of ties at life of 8 years.....	.08	.21
8	Depreciation of rails, spikes, etc. (practically 0)		
9	Interest on 900 to 2100 ft. 1/2-in. cable at 7 1/2 cents per ft.	.01	.02
10	Depreciation of cable at life of 600 days.....	.11	.26
11	Interest on hoisting drum (practically 0)		
12	Depreciation of hoisting drum, oil, etc.....	.02	.04
13	Cost of power for drum at \$35.00 per h. p. per year, 5 to 10 h. p. used.....	.58	1.16
	Total	10.21	16.28

Minimum cost per ton with probable maximum output
10.21
of 225 tons = $\frac{10.21}{225}$ = 4.54 cents.
Maximum cost per ton with probable minimum output of
16.28
200 tons = $\frac{16.28}{200}$ = 8.14 cents.

COST OF HANDLING CLAY OR SOFT SHALE WITH A 35-TON STEAM-SHOVEL AND CABLE HAULAGE.

ITEM.	Machines and Materials Used.	Per 10-hr. Day.	
		MIN.	MAX.
	Interest on shovel. Investment \$5500 to \$7000	.73	.93
1-13	Items from 1 through 13 practically the same as above	9.75	15.61
	Total	10.48	16.54

Minimum cost per ton with probable maximum output
10.48
of 325 toos = $\frac{10.48}{325}$ = 3.23 cents.

Maximum cost per ton with probable minimum output
16.54
of 260 tons = $\frac{16.54}{260}$ = 6.37 cents.

COST OF HANDLING CLAY OR SOFT SHALE WITH A 45-TON STEAM-SHOVEL AND CABLE HAULAGE.

ITEM.	Machines and Materials Used.	Per 10-hr. Day.	
		MIN.	MAX.
1	Interest on shovel. Investment \$6000 to \$7500	.80	1.00
1-13	Item from 1 through 13 practically the same as above	9.75	15.61
	Total	10.55	16.61

Minimum cost per ton with probable maximum output
10.55
of 600 tons = $\frac{10.55}{600}$ = 1.75 cents.

Maximum cost per ton with probable minimum output
16.61
of 300 tons = $\frac{16.61}{300}$ = 5.53 cents.

COST OF HANDLING A HARD SHALE WITH A 60-TON STEAM-SHOVEL AND CABLE HAULAGE.

ITEM.	Machines and Materials Used.	Per 10-hr. Day.	
		MIN.	MAX.
1	Interest on shovel. Investment \$8000 to \$9000....	1.06	1.20
2	Cost of coal, 1 to 2½ tons at \$1.40 per ton.....	1.40	3.50
3	Oil, repairs, etc.....	.25	.50
4	Labor, 6 to 8 men at \$2.00 per day.....	12.00	16.00
5	Interest on 8 to 12 cars, at \$150 each	.16	.24
6	Interest on tracks of 800 to 2000 ft. or same construction as in 25-ton case	.04	.10
7	Depreciation of ties at life of 8 years	.08	.21
8	Depreciation of rails, practically nothing		
9	Interest on 900 to 2100 ft. ¾-in. cable, at 16 cents per ft.....	.02	.05
10	Depreciation of cable at life of 300 days.....	.50	1.10
11	Interest on hoisting drum, at \$2.00		
12	Depreciation of hoisting drum, oil, etc.....	.03	.05
13	Cost of power in hoisting 10 to 25 h. p. at \$35.00 per h. p. per year.....	1.16	1.74
	Total	16.70	24.69

Minimum cost per ton with probable maximum output
16.70
of 1000 tons = $\frac{16.70}{1000}$ = 1.67 cents.

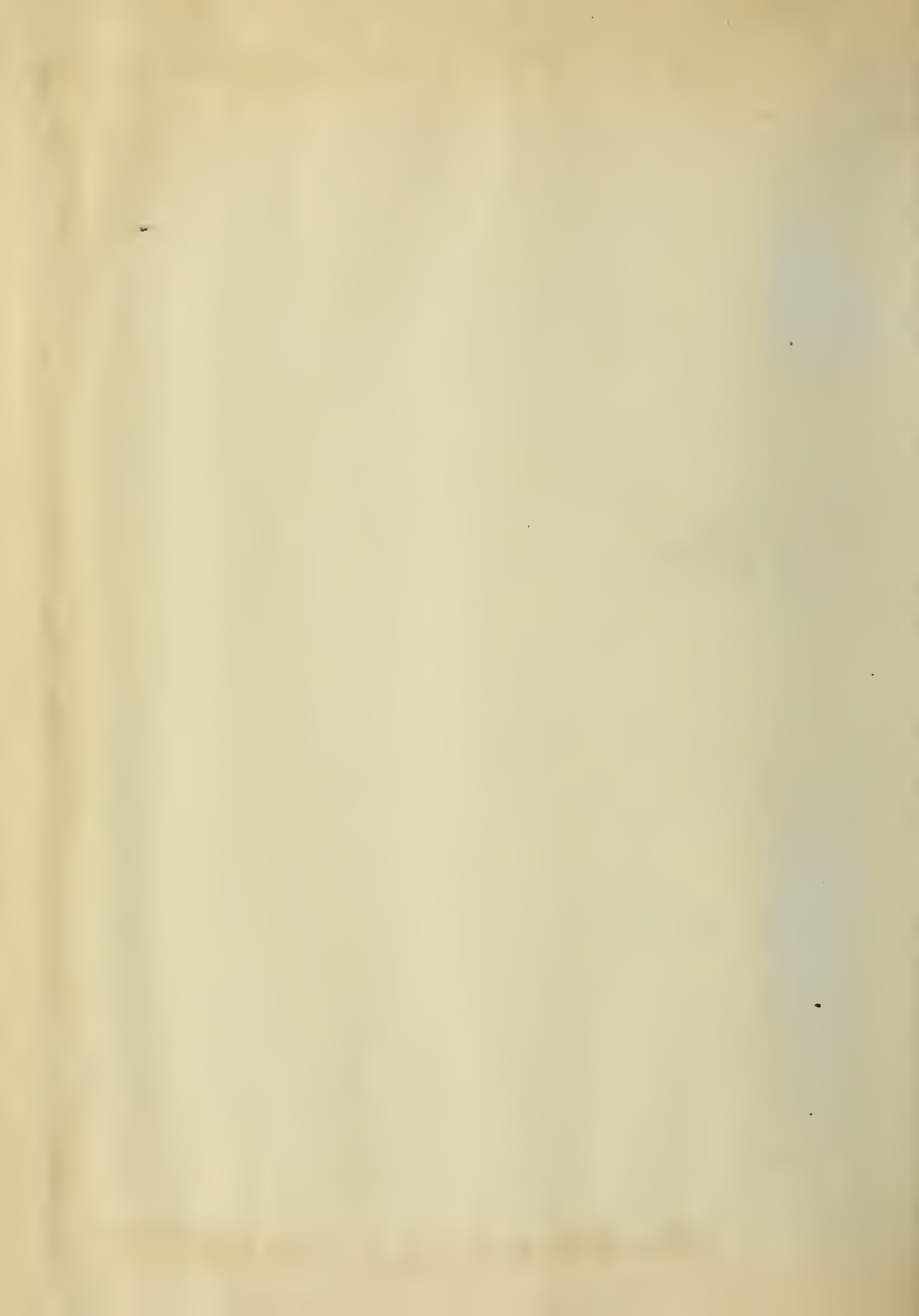
Maximum cost per ton with probable minimum output
24.69
of 400 tons = $\frac{24.69}{400}$ = 6.14 cents.

COST OF HANDLING A HARD SHALE WITH 60-TON STEAM-SHOVEL AND DINKEY LOCOMOTIVE WITH CABLE HAULAGE ON INCLINE.

ITEM	Machines and Materials Used.	For 10-hr. Day.	
		MIN.	MAX.
1-5	Items from 1 through 5 inclusive practically the same as in 60-ton case above	\$14.87	\$21.44
6	Interest on tracks using 35-lb. rails instead of 25-lb. as above for cable haulage only	.06	.16
7-8	Items 7 and 8 practically same as above 60-ton case	.08	.21
9	Interest on ¾-in. cable, at 16 cents per ft., 200 to 300 ft.		
10	Depreciation of cable at life of 300 days.....	.12	.18
11-12	Items 11 and 12 practically same as above 60-ton case	.03	.05
13	Cost of power in hoisting, at \$35.00 per h. p., 5 to 10 h. p. used.....	.58	1.16
14	Interest on locomotive, investment \$1200	.16	.16
15	Engineer on locomotive, at \$2.25 per day.....	2.25	2.25
16	Coal used in locomotive, ½-ton, at \$1.40.....	.70	.70
17	Repairs, oil, etc., on locomotive	.10	.25
	Total	\$18.95	\$26.56

Minimum cost per ton with probable maximum output
18.95
of 1100 tons = $\frac{18.95}{1100}$ = 1.70 cents.

Maximum cost per ton with probable minimum output
26.56
of 430 tons = $\frac{26.56}{430}$ = 6.18 cents.



COST OF HANDLING A HARD SHALE WITH 75-TON STEAM-SHOVEL
AND DINKEY LOCOMOTIVE WITH CABLE HAULAGE
ON INCLINE.

ITEM.	Machines and Materials Used.	For 10-hr. Day.	
		MIN.	MAX.
1	Interest on shovel. Investment \$9000 to \$10,000..	\$ 1.20	\$ 1.33
2	Cost of coal, at \$1.40, 2 to 4 tons	2.80	5.60
3	Oil, repairs, etc.....	.20	.50
4	Labor, at \$2.00 per day, 5 to 8 men.....	10.00	16.00
5	Interest on cars, at \$150 each, 8 to 12 cars.....	.16	.24
6-17	Items from 6 through 17, practically the same as second 60-ton case.....	4.08	5.12
	Total	\$18.43	\$28.79

Minimum cost per ton with probable maximum output
18.43
of 1250 tons = — = 1.47 cents.
1250
Maximum cost per ton with probable minimum output
28.79
of 600 tons = — = 4.80 cents.
600

COST OF HANDLING HARD SHALE WITH 90-TON STEAM-SHOVEL
WITH DINKEY AND CABLE HAULAGE ON INCLINE.

ITEM.	Machines and Materials Used.	For 10-hr. Day.	
		MIN.	MAX.
1	Interest on shovel. Investment \$10,000 to \$11,000.	\$ 1.33	\$ 1.46
2-3	Items 2 and 3 practically same as in 75-ton case.	3.00	6.10
4	Labor, at \$2.00 per day, 7 to 10 men.....	14.00	20.00
5-17	Items from 5 through 17 practically same as previous case	4.24	5.36
	Total	\$22.56	\$32.92

Minimum cost per ton with probable maximum output
22.56
of 1600 tons = — = 1.41 cents.
1600
Maximum cost per ton with probable minimum output
32.92
of 750 tons = — = 4.39 cents.
750

COST OF HANDLING A HARD SHALE WITH 110-TON STEAM SHOVEL
WITH DINKEY LOCOMOTIVE AND CABLE HAULAGE
ON INCLINE.

ITEM.	Machines and Materials Used.	For 10-hr. Day.	
		MIN.	MAX.
1	Interest on shovel. Investment \$11,500 to \$13,000.	\$ 1.53	\$ 1.73
2	Cost of coal, at \$1.40 per ton, 3 to 5 tons.....	4.20	7.00
3	Oil, repairs, etc.....	.40	.60
4	Labor, at \$2.00 per day, 8 to 12 men	16.00	24.00
5	Interest on cars, at \$150 each, 9 to 16 cars.....	.18	.32
6-12	Items from 6 through 13 practically same as above case of 90-ton... ..	.29	.60
13	Cost of power for hoisting, at \$35.00 per h. p. per year, 7 to 15 h. p. . .	.82	1.75
14-17	Item from 14 through 17 practically same as above cases	3.21	3.36
	Total	\$26.63	\$39.36

Minimum cost per ton with probable maximum output
26.63
of 2000 tons = — = 1.33 cents.
2000
Maximum cost per ton with probable minimum output
39.36
of 925 tons = — = 4.25 cents.
925

Notes on above data:—

All interest in table at 4% per annum.

Men's pay at \$2.00 per day of ten hours only a probable average.

Horse-power used in hoisting drums taken as about the average between no load and full load.

No cost of grading for track estimated because of great variation.

Power for hoisting drum figured same as if bought at cost; therefore no depreciation or interest on power plant of factory estimated.

It will be noticed that the addition of the dinkey engine somewhat increases the capacity of the clay-working plant as shown in the second 60-ton case.

Rise of cost per ton in 60-ton case due to change from soft shale and clays to a hard shale, such as could not be handled satisfactorily with any shovel lower than a 60-ton.

COST OF INSTALLATION FOR DIFFERENT CAPACITY OUTFITS—
25-TON SHOVEL.

25-Ton Shovel.		MIN.	MAX.
A	Cost of shovel	\$3000	\$5000
B	Cost of cars to \$125 each, 4 to 8 cars	500	1000
C	Cost of tracks, 25-lb. rails, at \$31.00 per ton, White oak ties at 50 cents each, laid 2 ft. between cen- ters; spikes, bolts, etc., at \$1.50 per 100 ft., 800 to 2000 ft. used	415	1036
D	Cost of ½-in. cable at 7½ cents per ft., 900 to 2100 ft.	67	157
E	Cost of hoisting drum....	200	250
F	Cost of power plant for hoisting drum not in- cluded		
Total		\$41.82	\$7443

4182

Minimum cost of installation per ton-weight = $\frac{4182}{25} =$

\$167.

7743

Maximum cost of installation per ton-weight = $\frac{7743}{25} =$

\$298.

35-TON SHOVEL.

35-Ton Shovel.		MIN.	MAX.
A	Cost of shovel.....	\$4500	\$7000
	Items from B through F practically same as in above	1182	2442
Total.....		\$5682	\$9442

5682

Minimum cost of installation per ton-weight = $\frac{5682}{35} =$

\$162.

9442

Maximum cost of installation per ton-weight = $\frac{9442}{35} =$

\$270.

45-TON SHOVEL.

45-Ton Shovel.		MIN.	MAX.
A	Cost of shovel.....	\$6000	\$7500
B-F	Items from A through F same as above.....	1182	2443
Total		\$7182	\$9943

7182

Minimum cost of installation per ton-weight = $\frac{7182}{45} =$

\$159.

9943
Maximum cost of installation per ton-weight = $\frac{9943}{45} =$

\$221.

60-TON SHOVEL (CABLE HAULAGE).

60-Ton Shovel (Cable Haulage).		MIN.	MAX.
A	Cost of shovel.....	\$8000	\$9000
B	Cost of cars at \$150, 8 to 12 cars	1200	1800
C	Cost of track, 8000 to 2000 ft.	415	1036
D	Cost of ¾-in. cable at 16 cents per ft., 900 to 2100 ft.	144	336
E	Cost of hoisting drum....	200	250
Total		\$9959	\$12,422

9959

Minimum cost of installation per ton-weight = $\frac{9959}{60} =$

\$161.

12422

Maximum cost of installation per ton-weight = $\frac{12422}{60} =$

\$207.

60-TON SHOVEL (DINKEY AND CABLE HAULAGE).

60-Ton Shovel (Dinkey and Cable Haulage).		MIN.	MAX.
A-B	Same as above 60-ton case	\$ 9200	\$10,800
C	Cost of tracks same as above except 35-lb. rails used	196	1240
D	Cost of ¾-in. cable at 16 cents, 200 to 300 ft....	36	54
E	Cost of drum F (see 25- ton case)	200	250
G	Cost of dinkey locomotive.	1200	1500
Total.....		\$11,132	\$13,844

11132

Minimum cost of installation per ton-weight = $\frac{11132}{60} =$

\$185.

13884

Maximum cost of installation per ton-weight = $\frac{13884}{60} =$

\$230.

75-TON SHOVEL.

75-Ton Shovel.		MIN.	MAX.
A	Cost of shovel.....	\$ 9000	\$10,000
B-G	Same as 60-ton, second case	2132	4544
Total		\$11,132	\$14,544

$$\text{Minimum cost of installation per ton-weight} = \frac{11132}{75} =$$

\$148.

$$\text{Maximum cost of installation per ton-weight} = \frac{14544}{75} =$$

\$194.

90-TON SHOVEL.

90-Ton Shovel.		MIN.	MAX.
A	Cost of shovel.....	\$11,500	\$13,000
B	Cost of cars, 9 to 16 at \$150 each	1350	2400
C-G	Items C through G same as above 90-ton case...	1932	2544
Total		\$14,782	\$17,944

$$\text{Minimum cost of installation per ton-weight} = \frac{13132}{90} =$$

\$146.

$$\text{Maximum cost of installation per ton-weight} = \frac{15844}{90} =$$

\$176.

110-TON SHOVEL.

110-Ton Shovel.		MIN.	MAX.
A	Cost of shovel	\$10,000	\$11,000
B	Cost of cars at \$150, 8 to 12 cars	1200	1800
C-G	Items C through G, inclu- sive, same as above case.	1932	3044
Total		\$13,132	\$15,844

$$\text{Minimum cost of installation per ton-weight} = \frac{14782}{110} =$$

\$134.

$$\text{Maximum cost of installation per ton-weight} = \frac{17944}{110} =$$

\$163.



CONCLUSIONS DRAWN AS TO BEST METHODS OF HANDLING
CLAYS UNDER VARIOUS CONDITIONS.

The following conclusions have been drawn from the cost data published in the March number of this magazine under the title of Methods and Estimates of Cost of Handling Clay and Clay Materials. The conditions to be carried in mind are:

Thickness of bank:

- I, banks under 5 feet in thickness.
- II, banks between 5 feet and 22 feet in thickness.
- III, banks over 22 feet in thickness.

Quantity used:

- 1, 20,000 to 50,000 capacity (50 to 140 tons)
- 2, 50,000 to 80,000 capacity (140 to 225 tons)
- 3, 80,000 to 100,000 capacity (225 to 280 tons)
- 4, 100,000 capacity upward (280 tons upward)

Density in bank:

- a, glacial, loess or soft shale clay.
- b, hard shale.

I.

1-4, a. Spading necessary in some cases where deposit is only a foot or two in thickness, and clay must be rather carefully picked over as in several Wisconsin plants (cost 17 cents to 40 cents per ton)

Wheel scrapers or clay gatherers with tramcar most

economical under such conditions that they can be used. (cost 5 cents to 10 cents per ton).

Steam shovels cannot be operated economically in such a bank.

1-4, b. Such deposits of hard shale seldom found, and very rarely worked.

II.

1, a. Spading out of the question in almost every case.

Wheel scrapers and clay gatherers with the tramcar necessary for most economical operation where clay is air dried upon the pit, or must be mixed in proportions not found as the clay lies in the bank. (cost 4 cents to 9 cents per ton).

A 25 ton steam shovel may be used most economically in most cases if several days supply is handled by continually operating the plant.

1, b. A hard shale is seldom used in so small a plant, but when used is excavated by blasting.

2, a. The same may be said of such a plant as was said in case 1, a.

The 25 ton steam shovel is amply large to excavate the required amount of clay .

2, b. Blasting generally resorted to if a hard shale is used. A 60 ton steam shovel such as would be necessary to stand the heavy strains of excavating such a shale might be

used economically in a few cases.

3, a. Wheel scrapers and clay gatherers necessary in cases mentioned in 1, a.

35 ton steam shovel most economical means of excavating in a majority of cases. (cost 4 cents to 7 cents per ton).

3, b. A 60 ton steam shovel is the most economical means of excavating the shale (cost 5 cents to 8 cents per ton).

Blasting and loading by hand cost approximately 12 cents per ton in this case.

4, a. Wheel scrapers no more economical than in case 1, a.

A 45 ton steam shovel most economical for 100,000 capacity plant, and will handle sufficient clay for a 150,000 capacity plant under favorable conditions.

4, b. A 60 ton steam shovel will handle satisfactorily a shale of almost any density in amounts sufficient for a 100,000 capacity plant. Larger plants require correspondingly larger shovels.

III.

1-4, a and b. Where glacial clays and shales are found in bank over 22 feet in depth and the entire depth is to be worked the safest plan and the one generally followed is to divide the bank into two cuts. The costs are practically the same as in section II.

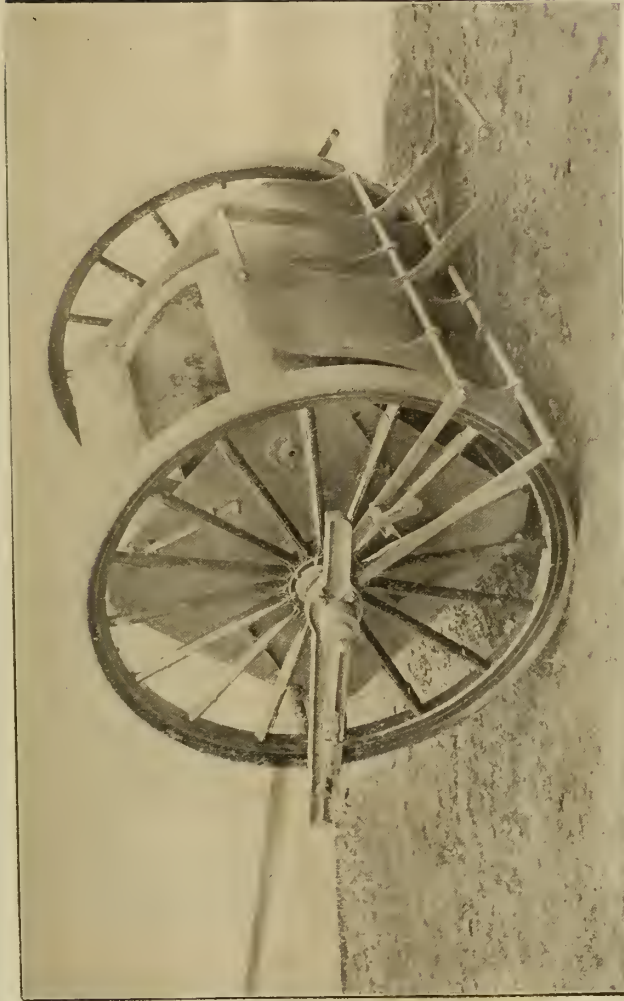
NOTES.

The brick used as a basis for figuring capacities of plants was the standard common brick which has an average weight of 5.6 pounds of green clay size (8 1/4 inches by 4 inches by 2 1/2 inches)

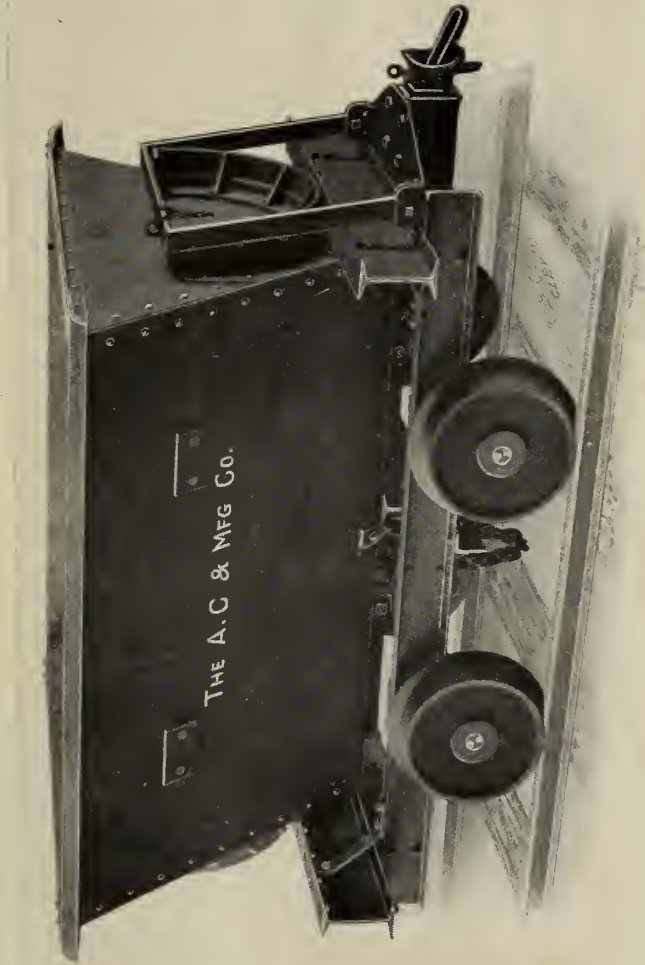
Cost per ton delivered at shed given in estimates.

All interest, depreciation and repairs taken into account when estimating costs per ton.

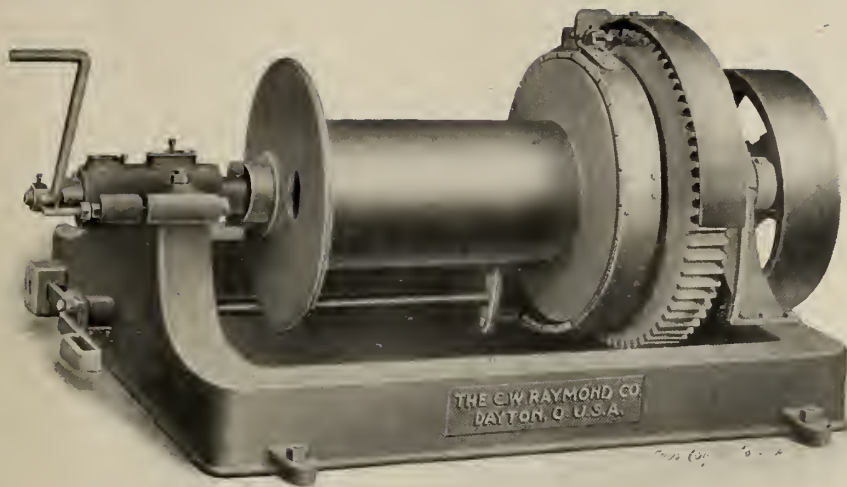
Where shovel is not run up to its capacity and is "loafing" a part of the time very little difference in operating expenses per day can be allowed and the increase of cost per ton must be taken into account as in same cases above.



Clay Gatherer.
Fig. 63.

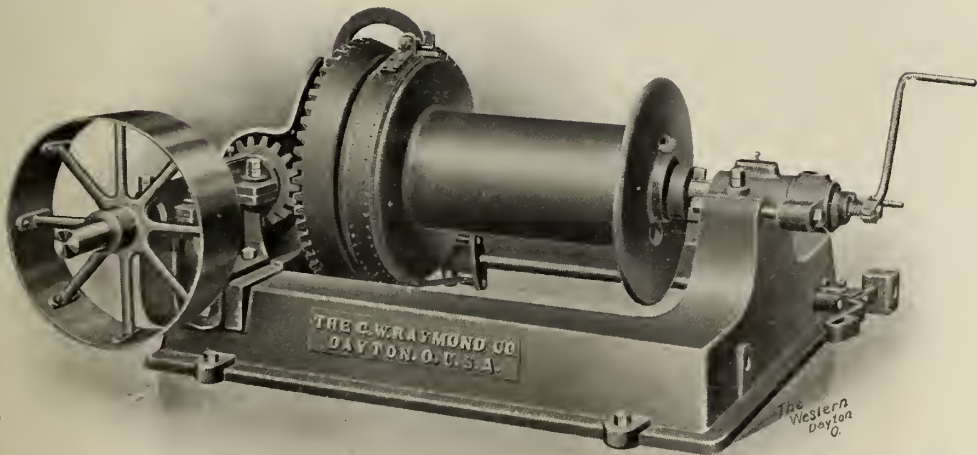


Clay Car. Fig 64.



SPUR GEARED

Fig. 65.



BEVEL GEARED

Hoisting Drum.
Fig 66.

The clay upon being brought into the plant for reduction is, either dumped directly into a granulator or dry pan, or into a storage bin from which it is taken by means of an underground belt or chain conveyor to the rolls, granulator, pan, or other reducer. The belt conveyor seems to be the best type for this work as it requires less power to operate and wears longer. The present price of conveyors of the chain type almost prohibit their use around such a plant. When a belt is used, it generally rests upon rolls of an increasing diameter from the middle out to the ends so that the belt forms a trough, and the clay is not scattered along the way to the machine. The chain conveyor consists of two flat chains with special links holding slats or cups between them, which drag or carry the material to its desired destination. Where slats are used excessive wears is sure to take place because of the rubbing of the slats upon the trough in which they run. In the use of such conveyors it has been found that above 25° from the horizontal, (the angle up to which a smooth belt will carry fine clay satisfactorily) the chain conveyor must be used.

After the clay has passed through the pan or crusher, it is necessary to screen it if it is dry. Such a screen as is generally used is of considerable length if stationary and it must therefore be placed a considerable distance above the pug-mill so that the screened clay may run into a bin for storage above that mill, or run directly into the mill itself. This

elevation requires that a long conveyor or elevator be used, and, since in very few cases it is practicable to use a long inclined belt conveyor, a vertical or slightly inclined belt or chain cup elevator is used. The slightly inclined has an advantage over the vertical, in that the dust in being shaken from the rising buckets does not follow the chains or belt back to the boot or lower housing in falling. The links of the chains are therefore saved, and the boot sprocket or pulley will run better.

In case a wet-pan is used the clay is generally taken from the pan to the feeder of the moulding machine by a vertical belt cup elevator. In potteries and terra cotta works, the clay from the wet pan or pug-mill is run through a machine, which pushes it out in a long thick column which is cut up into pieces for convenient handling and laid by hand upon swinging shelves of a chain elevator and taken to one of the several floors upon which the hand moulding is done. The small amount of clay used, and the several floors upon which it is to be used makes this scheme practicable.

Clay is transferred from bins to moulding or pugging machines as in the dry-press and stiff mud processes by means of spouts or troughs through which it runs by gravity. Such troughs should not be set at less than an angle of 50° from the horizontal.

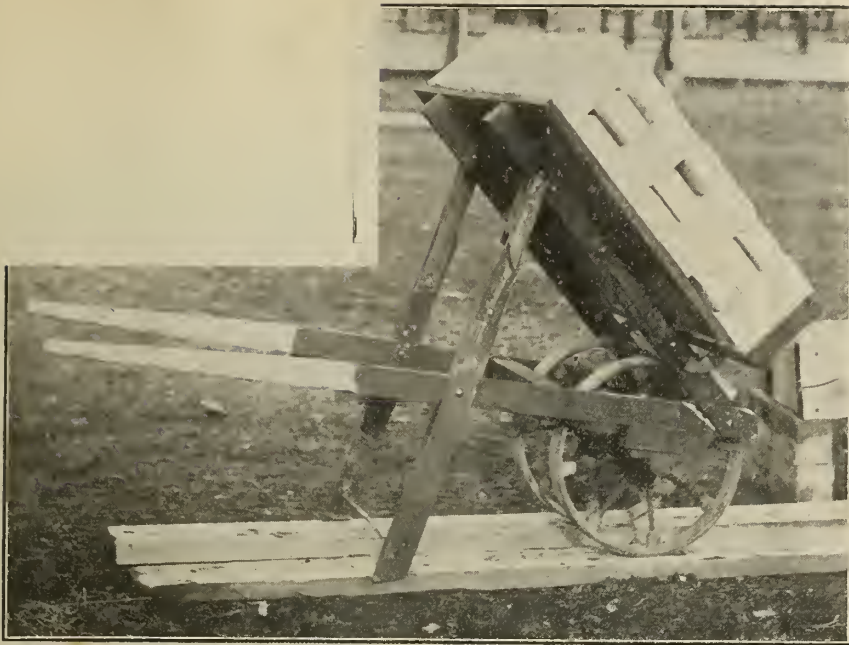
Clay from pug-mills, rolls, and disintegrators generally drops into the next machine in the line of the process, and thus saves elevators, but heavy foundations are required



for the elevated machines, and therefore a slightly increased cost of installation, but a great saving of power.

The green product in coming from the cutting table is taken off by hand, or carried out on rolls or belts to distances at which it can be more conveniently removed. Since the clay in coming from the machine is in a rather tender state, no machine has ever been perfected which will pick up the green material, and transfer it to the pallets, cars, or barrows. (The pallets shown in figure 68 are representative of the sizes in which they are made). In case the dry-press process of moulding is used, the product is taken directly from the press table, and placed upon barrows on which it is taken directly into the kiln, and burned as shown in figure 149. In the stiff mud process the product is set upon barrows, cars or elevator shelves. Figure 67 shows one type of barrows used. Another is a flat platform barrow upon which the ware is carried to the racks or slotted floors of the dryer. Where cars are used, the ware is set directly from the machine or delivery belt upon the platform of the cars. Two typical types of such cars are shown in figures 69 and 70. They are the single and multiple deck cars respectively. A transfer for taking each car to its particular dryer track is shown in figure 71 and in figure 72 is shown a turntable transfer such as is often necessary to use in some transfer systems, but should be avoided if possible. In some cases, the stiff mud product is piled several tiers deep upon heavy wooden pallets laid upon loading racks. The pallets are then transported to similar dry-

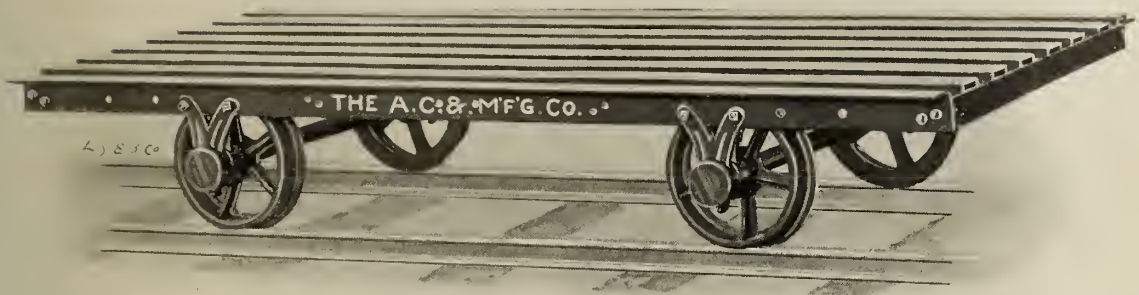




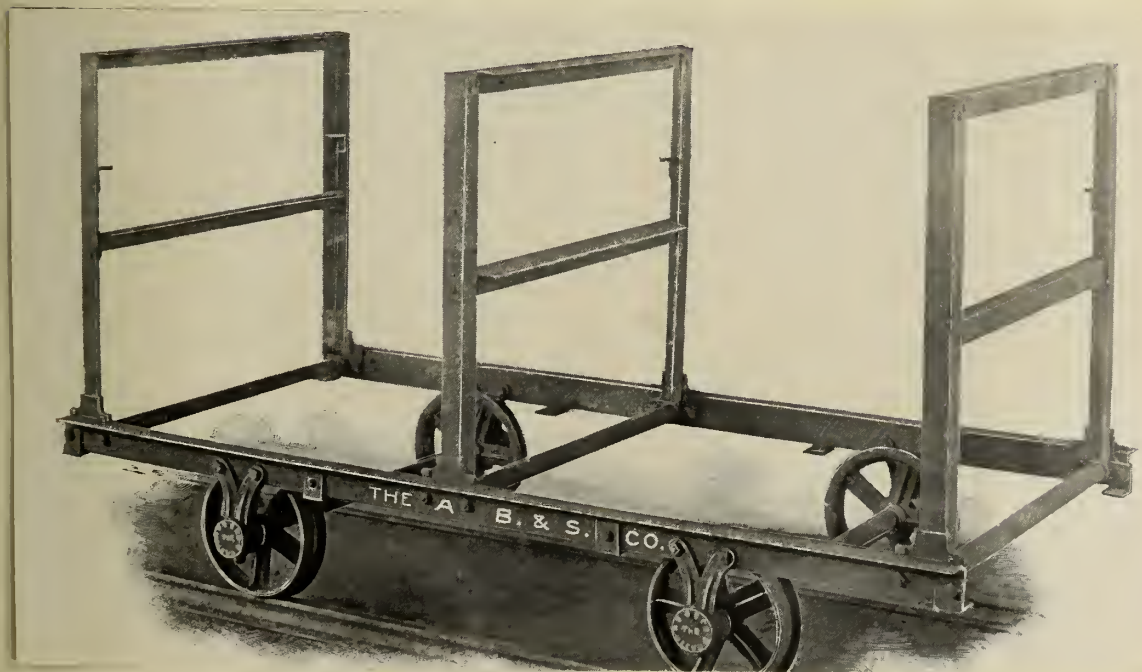
Stiff Mud Brick Truck.
Fig 67.



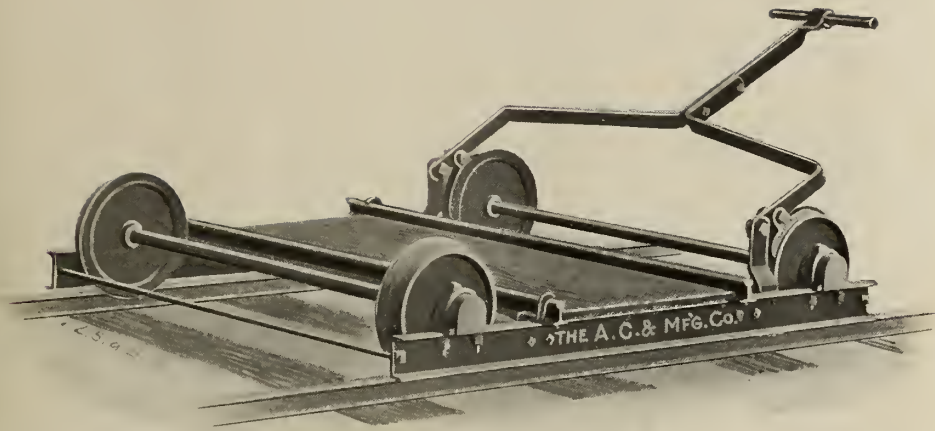
Soft Mud Brick Truck
Fig. 68.



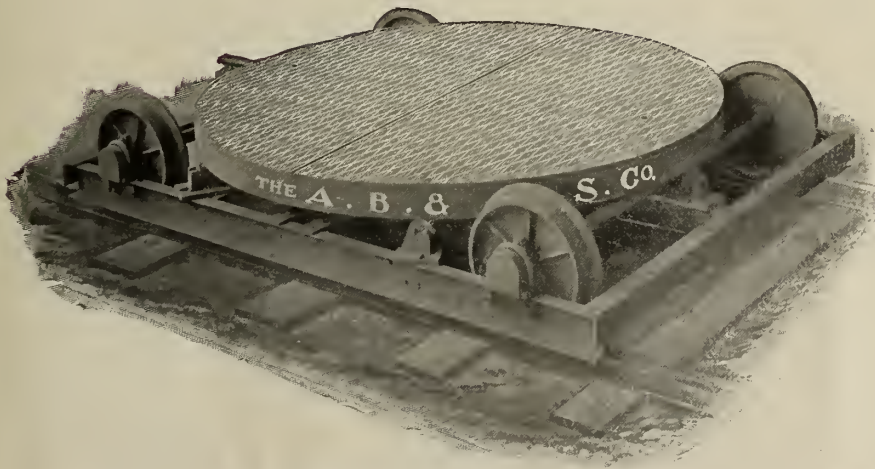
Stiff Mud Brick Car.
Fig. 69.



Stiff Mud Brick Car
Fig. 70.



Transfer Car.
Fig. 71.



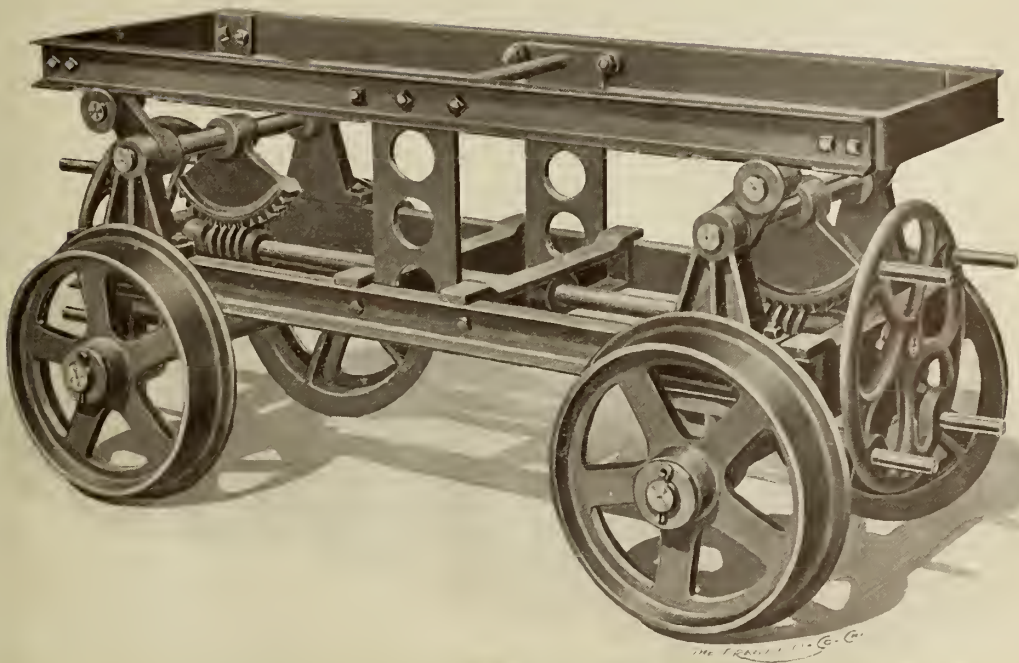
Transfer and Turntable Car.
Fig. 72.

ing racks by a lift car shown in figure 73 and also in figure 74.

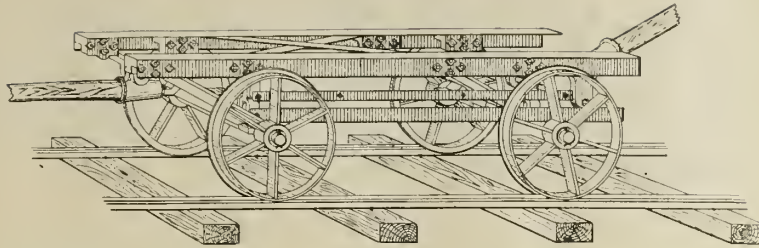
In the soft mud process, the brick are always laid on palates upon being removed from the moulds. The palates may be taken to a rack dryer on trucks as shown in figure 68 or on cars as shown in figure 75.

Where cars are used provision is generally made for taking the dried ware upon the cars directly into the kiln from the dryer, without any intermediate handling. Where racks or slatted floors are used the ordinary hand barrows with the single wheel are generally found to be the most convenient.

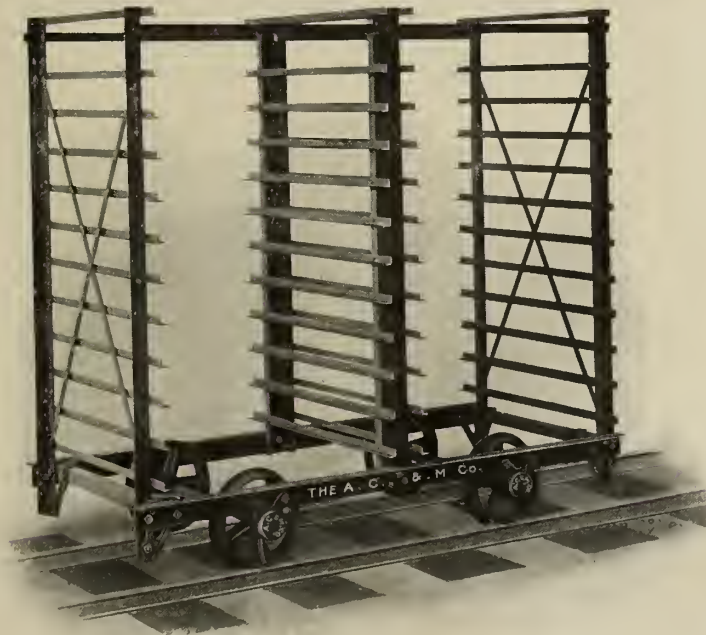
Where various systems using trucks and barrows are in use, it is sometimes necessary to use more than one story in the dryers. The elevating to these upper stories is accomplished in two ways in most cases. 1. By setting the ware upon trucks at the machine or conveyor, and elevating the truck and ware. 2. By setting the ware upon shelves which move up to the floor and where it is removed at the desired floor to trucks. The first method has the advantage of a smoother product due to less handling but requires more power. The decrease of labor in the first method more than balances the increase of power used. The second method is not the best for large plants because of the disadvantage of using more than one set of elevator shelves. In the first method, several trucks may be loaded at one time.



Lift Truck.
Fig 73



Lift Truck
Fig. 74.



Palate Car
Fig. 75.

In trans porting the ware to the kiln by conveyors, several systems are in general use.

1. The Scott system operates with a line of belt conveyors directly from the machine to the kiln chamber. The ware is transfered from the belt directly attached to the cutting table to the belt running through the kiln by a man, since no satisfactory transferring arrangement has been made. Figure 151 gives a better insight into the manner of operating this system.

2. In the Martin system, the palates upon which the brick of either the soft mud or stiff mud process are laid or placed upon the cable conveyor as shown in figures 76 and 77 and taken to the dryer. After drying they are taken to the kiln entrances by the same conveyor as shown in figure 78.

3. Another common system used in transporting both green ware to the dryer, and dried ware to the kiln is the Barney conveyor arrangement. In this system, the brick are carried on hooks from the machine to the kilns or dryers, and from the kilns to the stock yards or cars. This system is shown in figures 79 to 84. The cost of power for operation is rather high in this system. The high cost of installation and maintainance is also a disadvantage in its use.

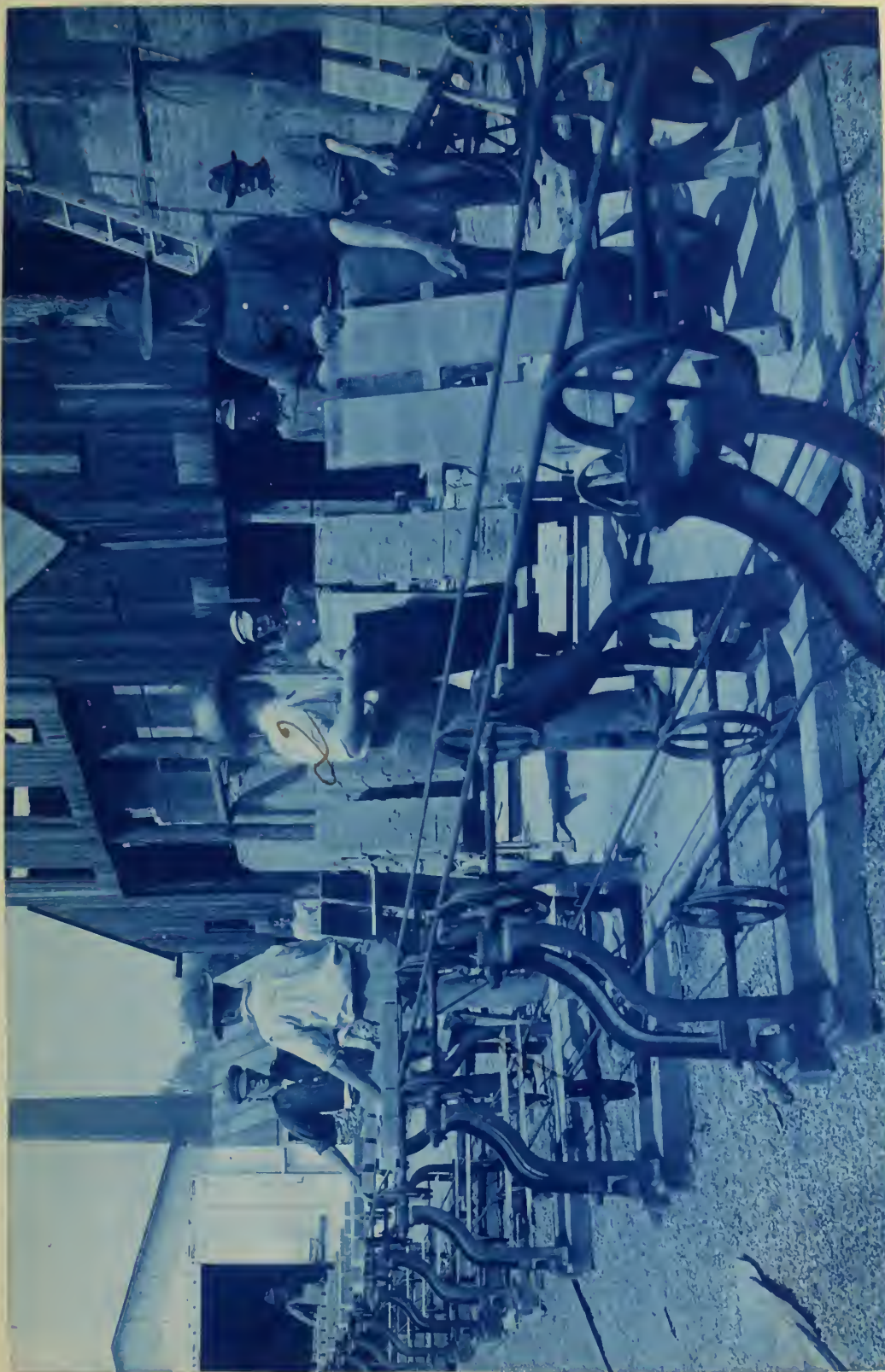
4. In the Fiske system, the brick are run out on a long delivery belt directly from the machine as shown in figure 84 and are piled in long hacks on each side of the belt. These hacks contain about 1800 brick, and weigh about 5000 pounds



A Martin Conveyor in use. Fig. 76.



Soft Mud Brick being taken to Dryer by a Martin Conveyor Fig. 77.



Handling Brick with Martin Conveyor
Fig. 78.



Fig. 79.



Fig. 80.



The Barney Brick Conveyor.

Fig. 81.



Fig. 82



The Barney Brick Conveyor.
Fig 83.

in the green. A traveling crane with a finger rack as shown in figure 84 lifts these hacks, and carries them to the drying floor. This drying floor makes use of the waste heat from the kiln, and has suitable fan blowers to keep the air going in, and coming out without becoming too cool. Figures 87 and 88 show a detailed plan of this dryer. After the brick are dried they are again picked up by the crane, and set in the semi-continuous kiln as shown in figure 90 after which the crown is set on as in figure 89. Figure 91 shows a hack just set in the kiln. Figures 92 and 93 show general plans of the whole plant.

Where the stiff mud process is used in connection with slotted floors, the loaded trucks or barrows generally are let down to the ground level by gravity elevators which allows the loaded barrow to descend while the empty barrow is brought up in another cage. This double cage arrangement is controlled by a differential brake around the drum upon which the rope is wound on and off. The single cage gravity elevators is balanced with weights in place of the other cage so that the loaded barrow will descend, and the weight of the empty barrow not being great enough to counter-balance the balancing weight will allow the cage to return with its empty barrow. Such arrangements are simple, inexpensive, and easy to control and are indispensable to some plants.

In the manufacture of sewer pipe, troughs are often

seen running down from the upper stories directly into the kiln. The ware is skided down these troughs without injury, and does away with a considerable amount of labor.

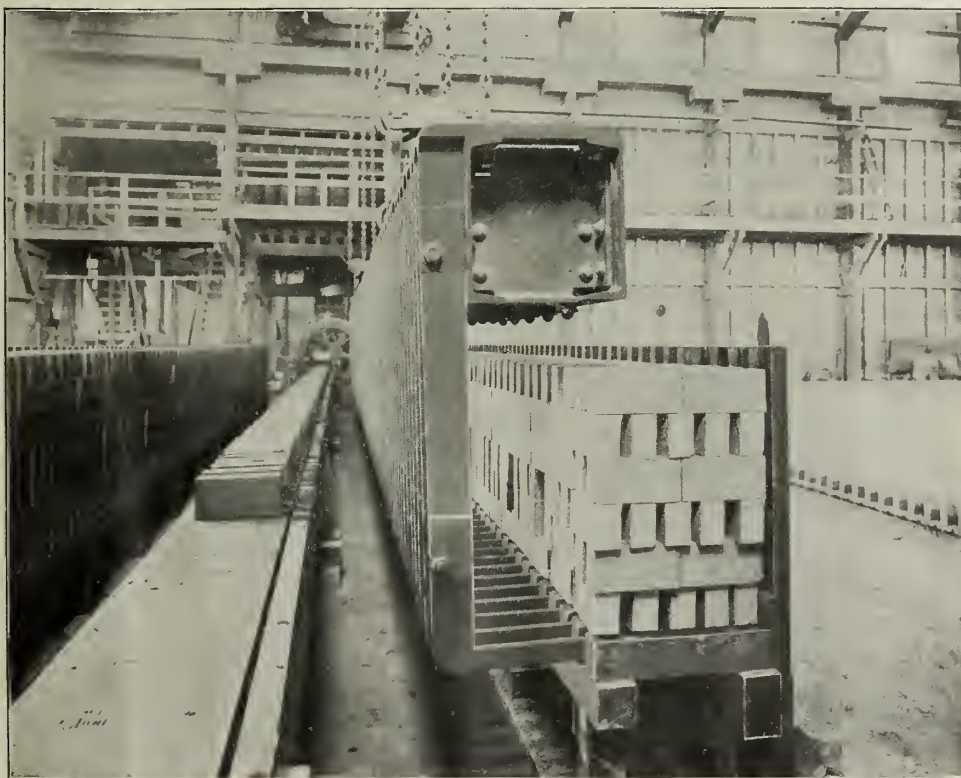


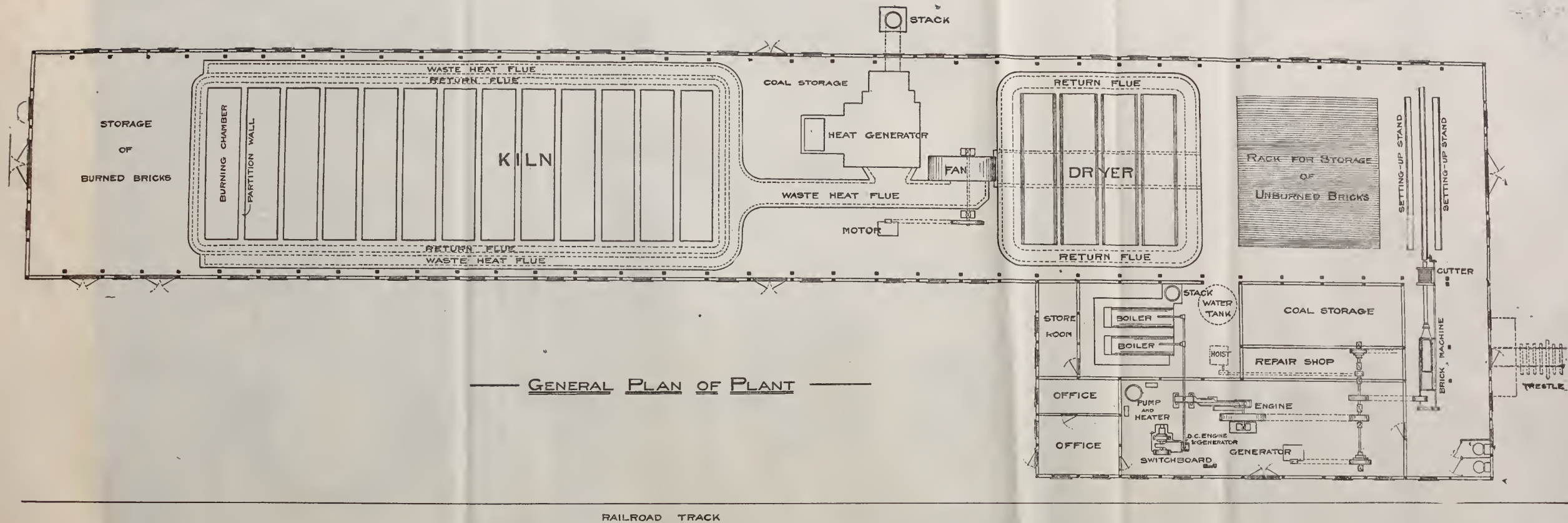
PLATE 6.—SHOWING THE FINGERS OF THE BRICK LIFT ENTERING THE SETTING-UP-STAND TO LIFT A STACK OF SOFT BRICKS THEREFROM.

The Fiske System.

Fig. 84.



Fig. 93.



THE FISKE BRICK MAKING SYSTEM.

— J.C. OSTRUP, —
CONSULTING ENGINEER.

BOSTON, MASS.
OCTOBER 1902.

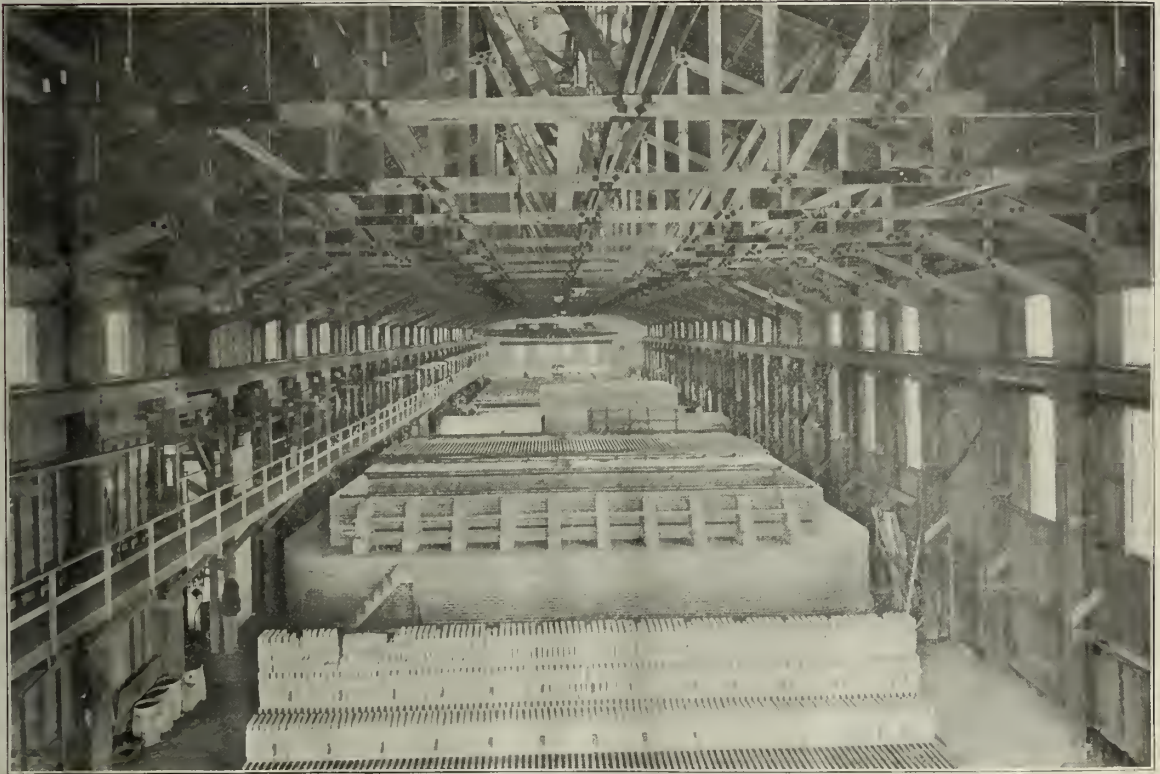


PLATE 3.—BIRDS EYE VIEW OF INTERIOR OF MAIN BUILDING, SHOWING STORAGE RACK FOR DRIED BRICK IN THE FOREGROUND.

Fig. 92.



PLATE No. —LOOKING DOWN INTO DRYER CHAMBER, THE COVER AND TWO PORTABLE RACKS BEING REMOVED.
TWO STACKS OF SOFT BRICKS ARE SHOWN, PLACED IN POSITION FOR DRYING.

Fig. 91.

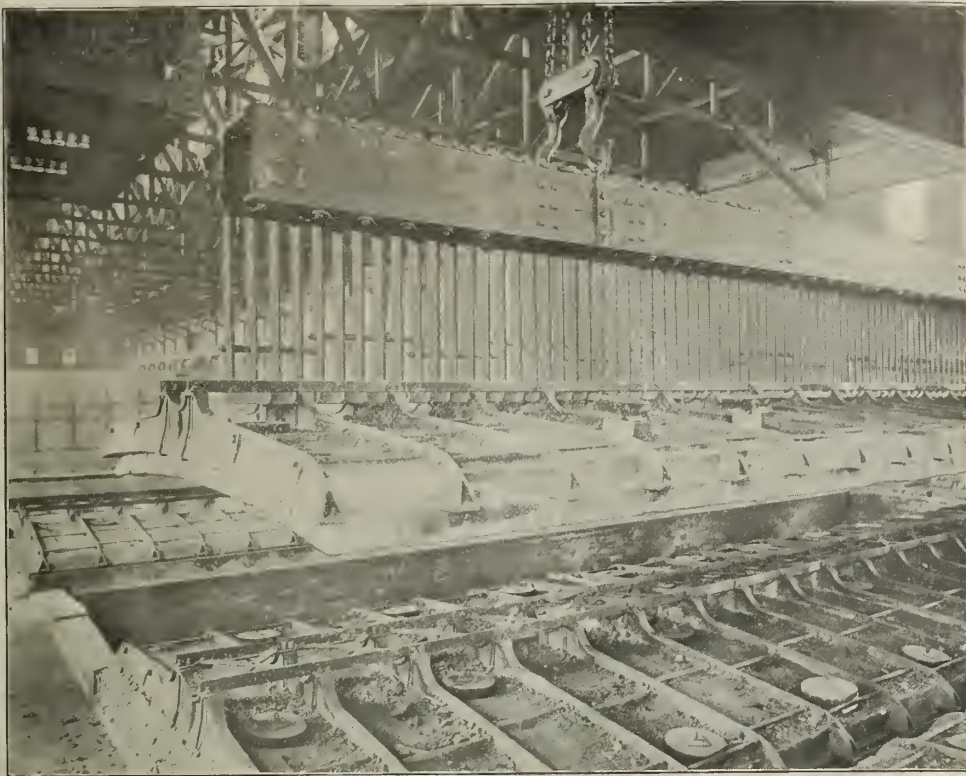


PLATE 16.—REMOVABLE KILN CROWN BEING HANDLED BY CRANE AND LIFT.

Fig. 89.

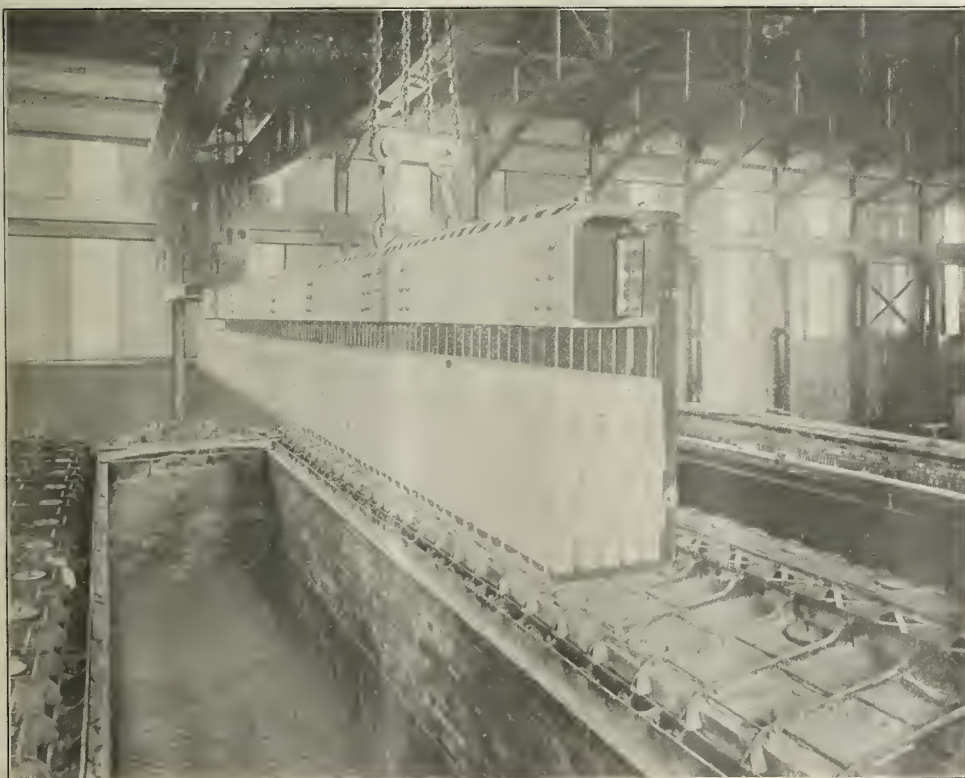
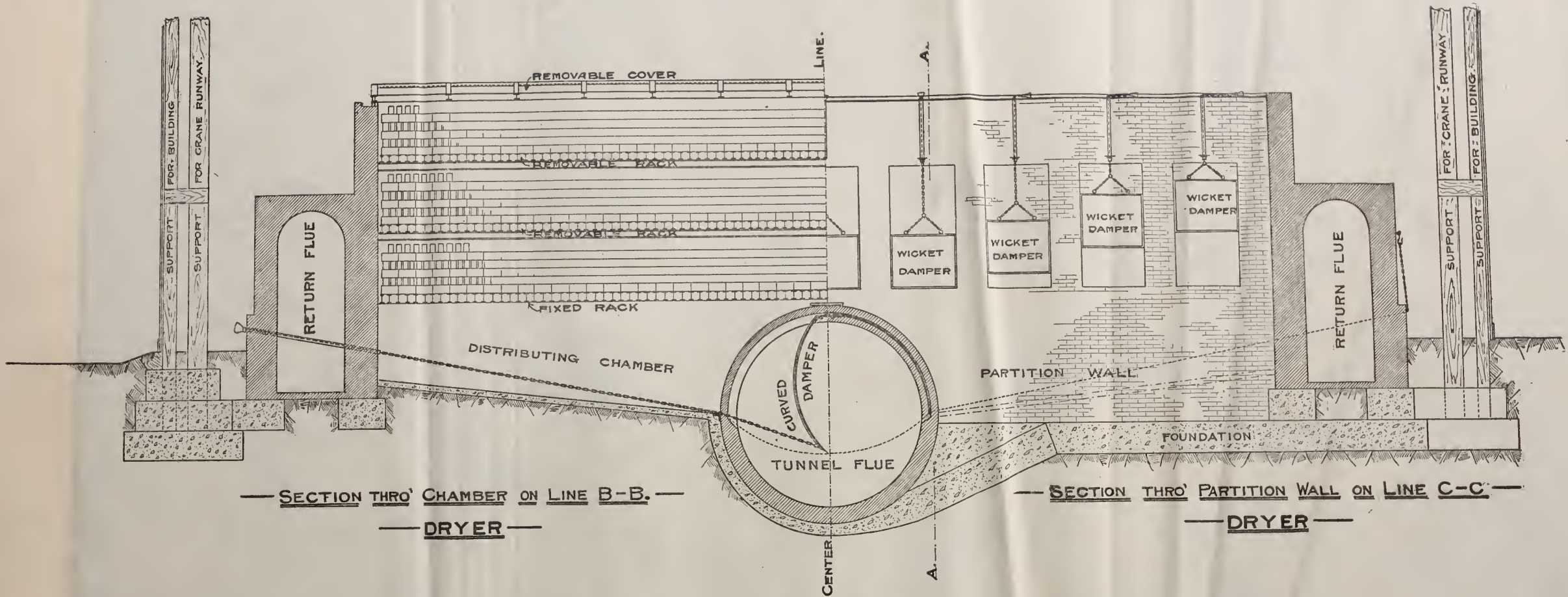


PLATE 13.—KILN CHAMBER WITH CROWN REMOVED, AND THE CRANE WITH STACK OF DRIED BRICKS READY FOR DEPOSIT IN THE KILN.

Fig. 90.



Fig. 88.



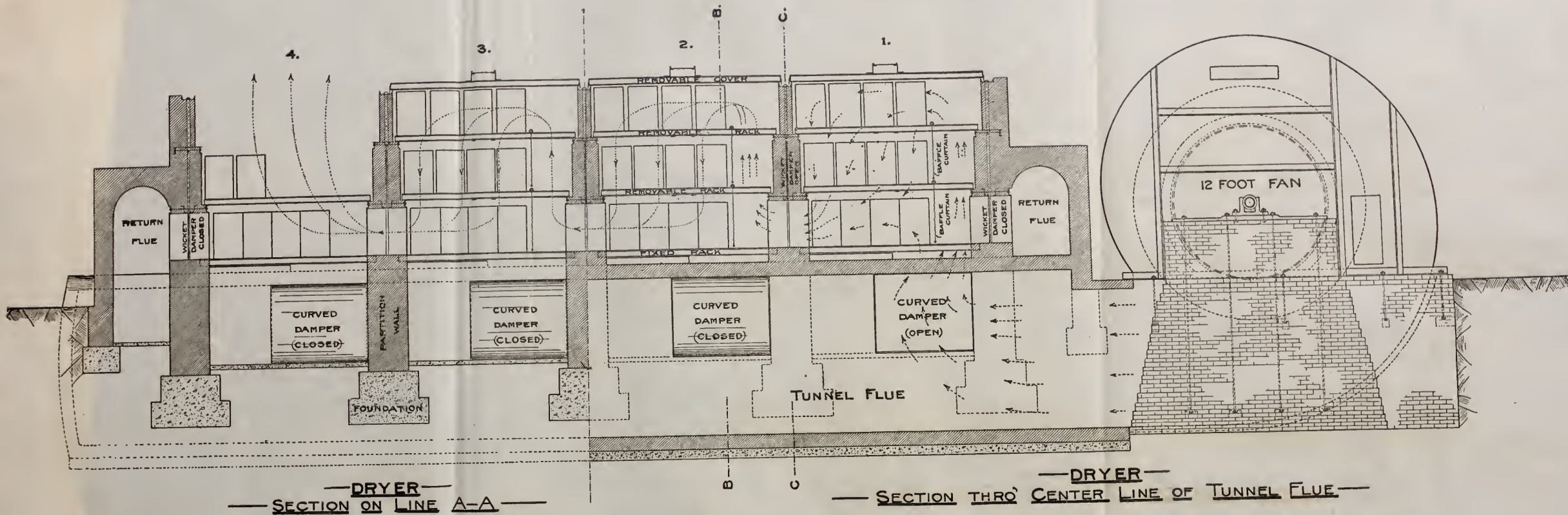
THE FISKE BRICK MAKING SYSTEM.

— J. C. OSTRUP, —
CONSULTING ENGINEER.

BOSTON, MASS.
OCTOBER 1902.



Fig. 87.



THE FISKE BRICK MAKING SYSTEM.

— J. C. OSTRUP, —
CONSULTING ENGINEER.

BOSTON, MASS.
OCTOBER 1902.

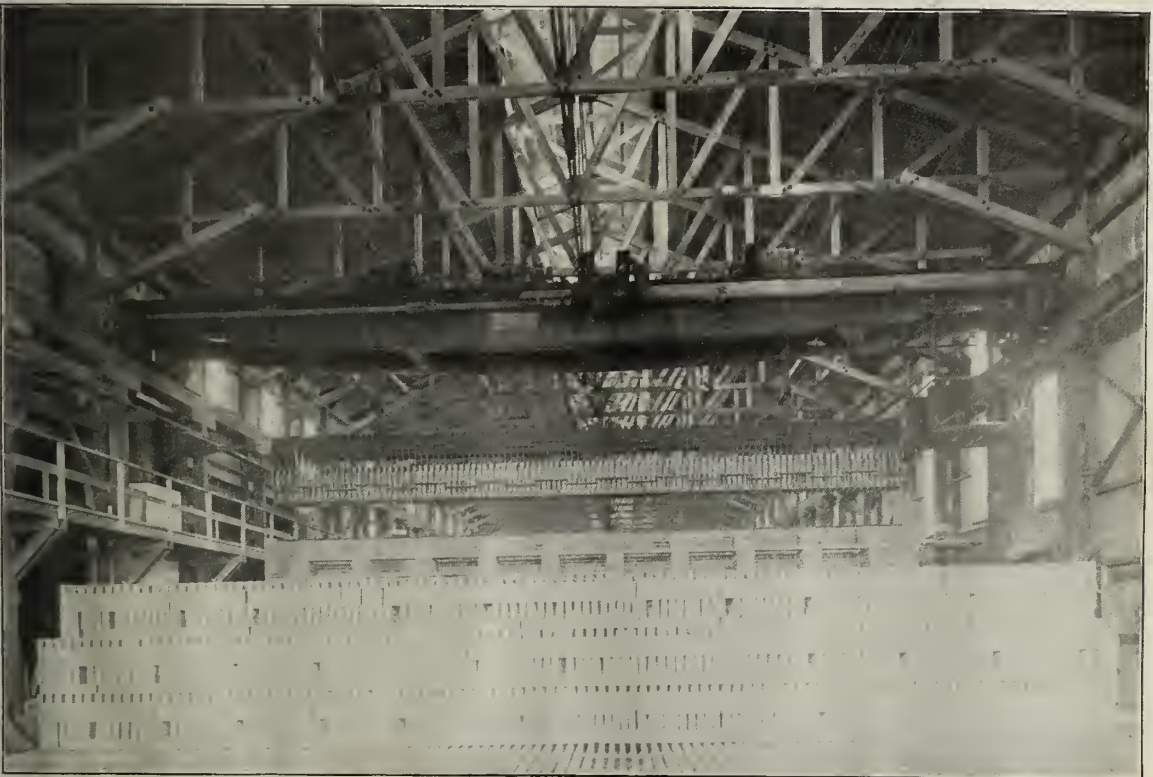


PLATE 1.—SHOWING CRANE TRAVELLING ON ELEVATED RUNWAY AND CARRYING A STACK OF SOFT BRICKS TO THE DRYER. DRIED BRICKS IN STORAGE IN THE FOREGROUND.

Fig 86

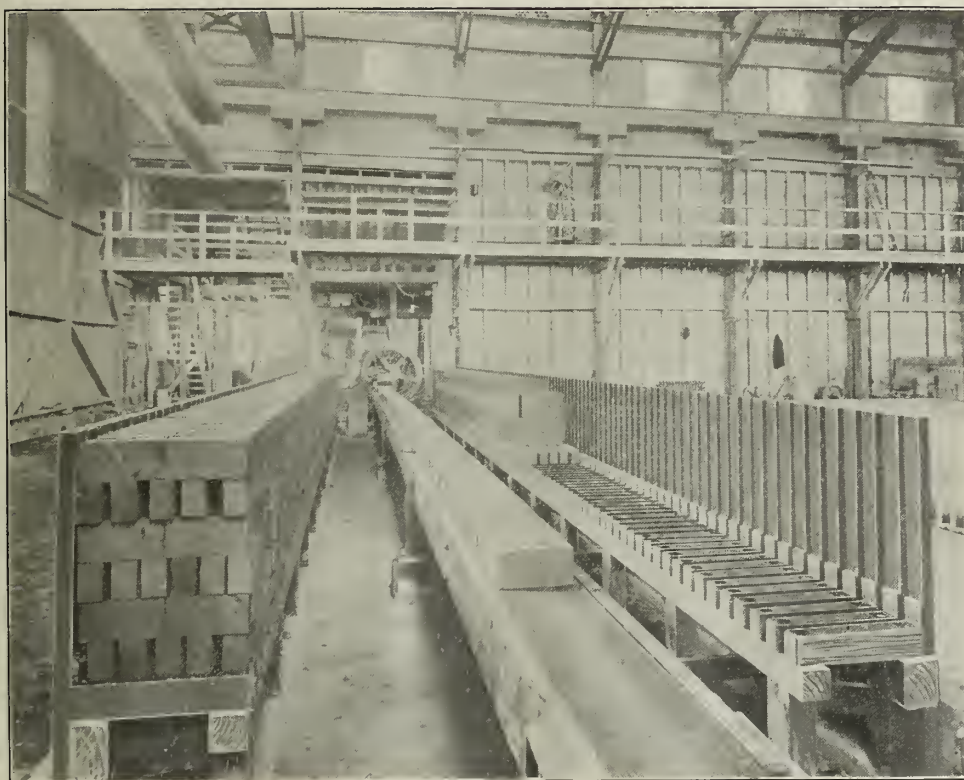


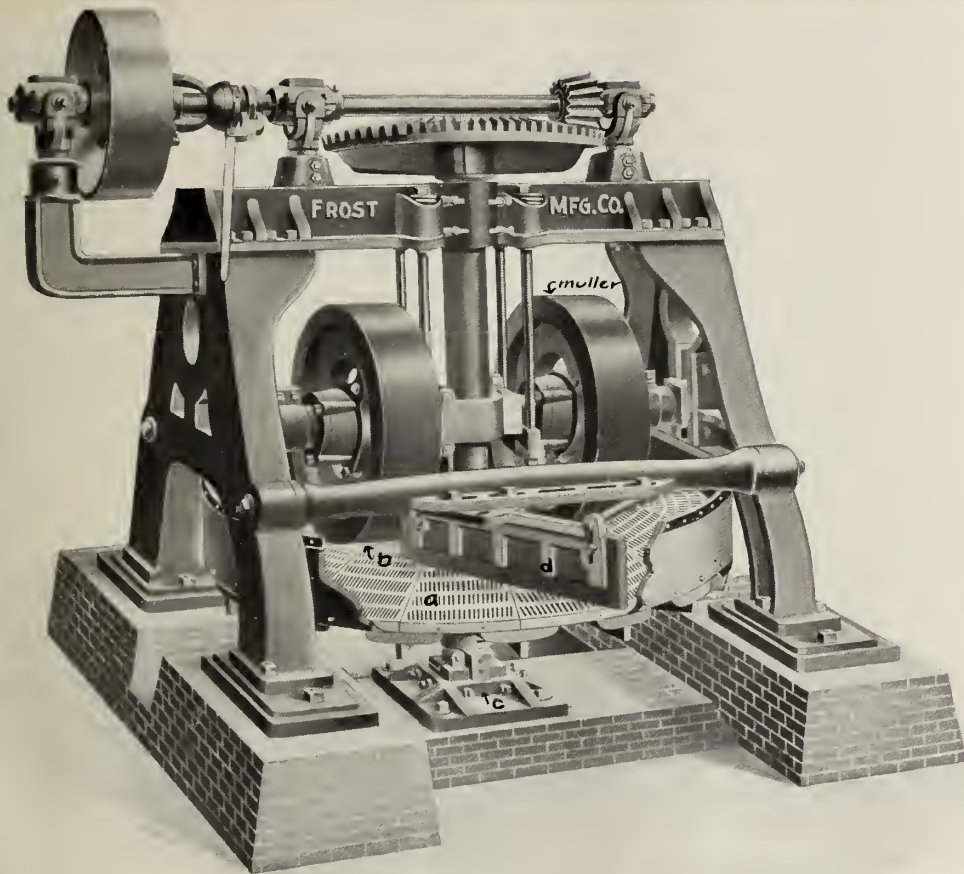
PLATE 4.—SETTING-UP-STANDS, ONE FILLED WITH SOFT BRICKS AND ONE PARTLY FILLED;
THE OFFBEARING BELT BEING BETWEEN THEM.

Fig. 85.

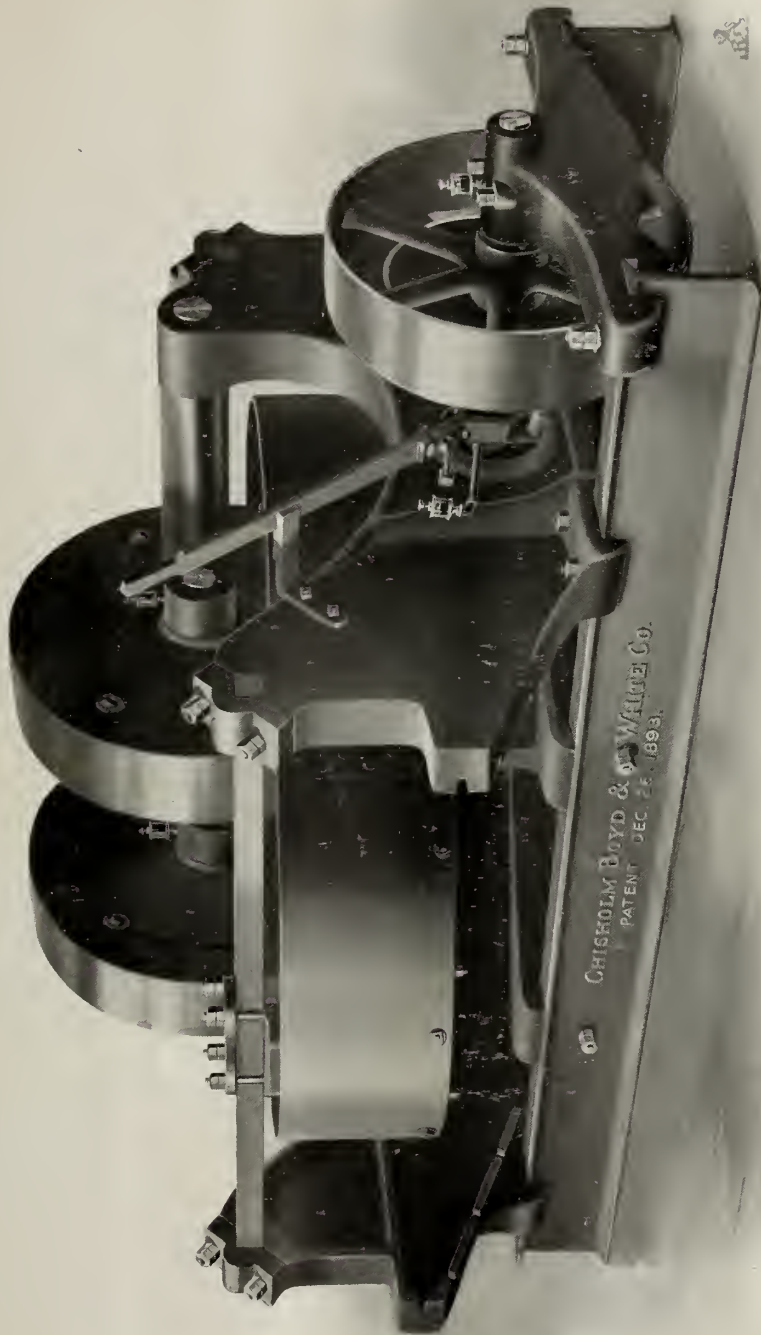
VIII. DESCRIPTIONS OF MACHINES USED.

1. **Crushers.** Foremost among the crushing machinery in use at the present day is the dry-pan. This machine will crush all sizes of shale chunks to any size desired above a ten mesh. The size to which the clay or shale is crushed depends upon the slots in the screen plates shown at a in figure 94, which make up as will be seen the largest part of the bottom of the pan. The solid plates immediately below the mullers, shown at b, are made thick and heavy because it is upon these that the crushing and grinding action takes place. The faces of the screen plates and bed plates as well as the mullers are chilled white casting, and wear very well considering the service they are put to. The weight of the pan with its contents of clay is upheld by the step bearing at c. The scrapers at d are so placed that the clay in the clockwise revolving pan is taken from near the outer rim where it is thrown by centrifugal force, and carried in so as to pass under the mullers. The weight of the mullers is generally carried by the frame of the pan, and the mullers can in no way rest upon the bed plate, when the pan is empty. The usual method of speed reduction is by bevel gears, as shown in the figure. Figure 95 shows an under-driven pan which has lately come into prominence. The large bevel gear is under the screen plates in this case, and, as will be noticed, does away with a considerable portion of the frame work required in the first described type.

The roll disintegrator is more used in the plants



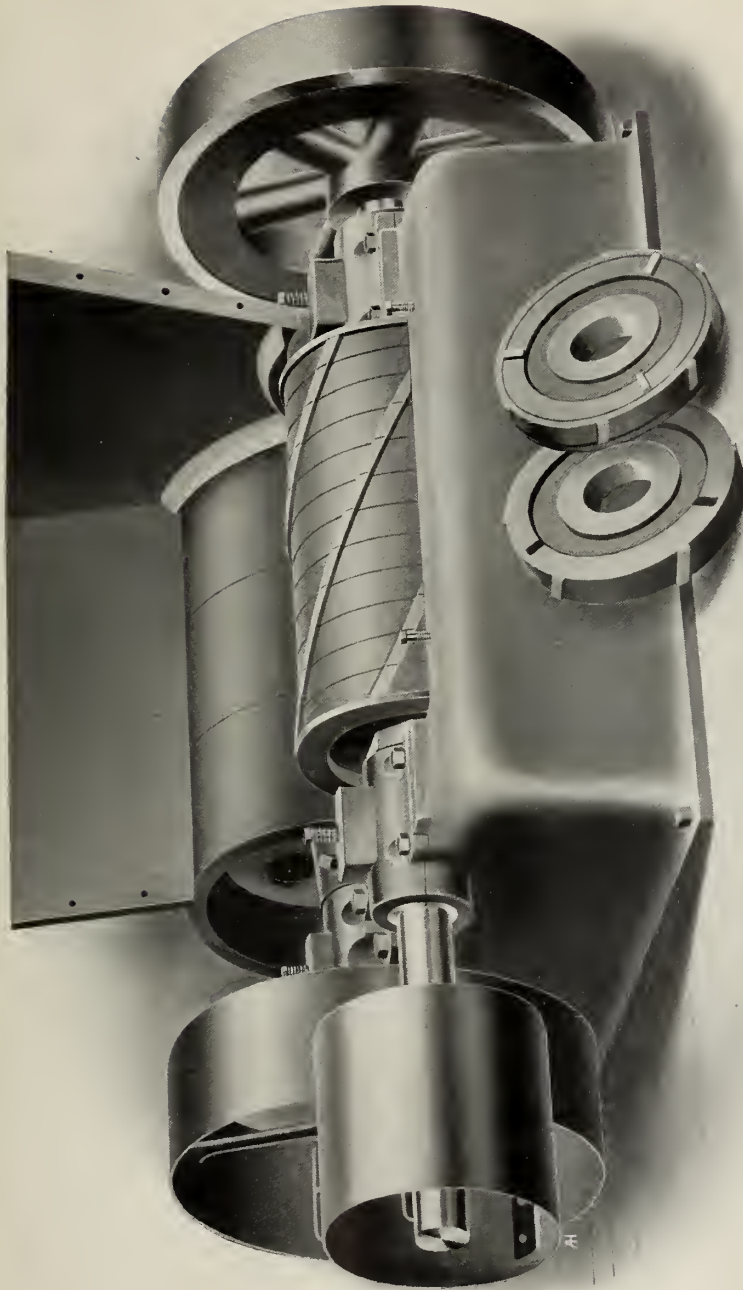
Dry Pan.
Fig 94.



Dry Pan.
Fig. 95.

in which the clay does not leave the plastic state at anytime during the reduction. The small roll in figure ⁹⁶ is rotated at a speed of 300 to 500 R. P. M. The knives on the surface cuts the clay into shreads at the same time crushing all small stones, and throwing the larger ones aside. Figure 97 shows an excellent sectional view of the straight knife disintegrator. The speed of the small roll is the same as in the one above. The speed of the large roll in both cases varies from 65 to 170 R. P. M. In most cases, the large roll is smooth. In place of the large and small cylindrical rolls, very often two conical rolls of the same size are used. In this form, the larger stones are rolled out one end. In all such crushers, provision is made for the adjustment of the rolls so the distance between their faces can be kept constant as they wear, or they can be set fine or course as the clay requires. There are many types of these rolls some with corrugated or spiral surfaces have been made to take care of particular conditions arising in the handling of certain clays.

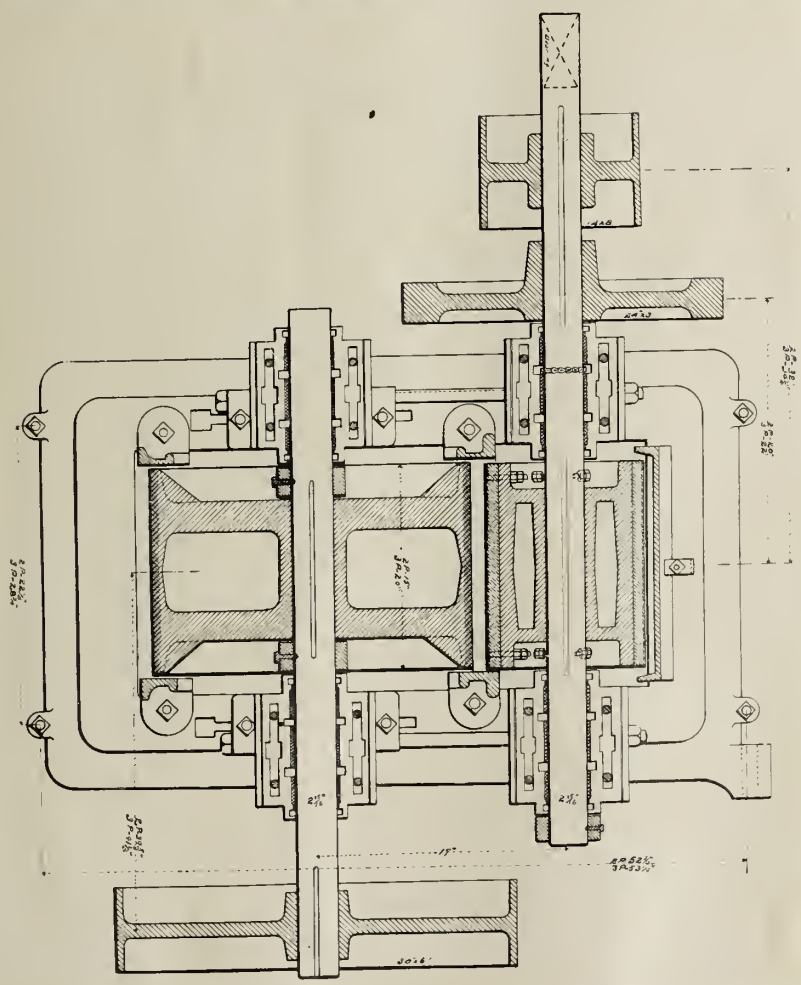
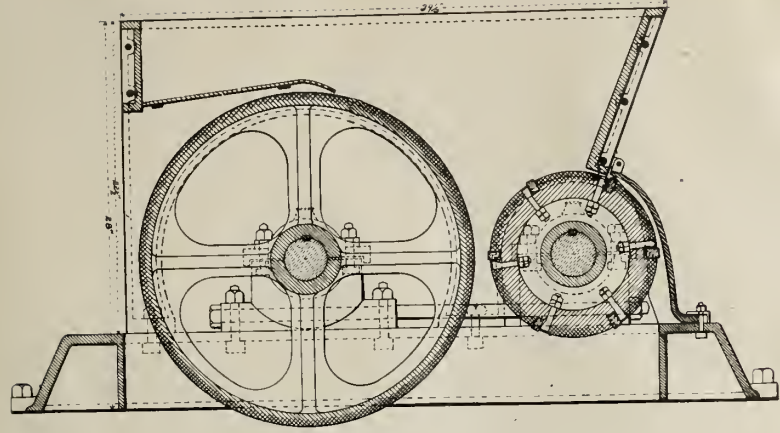
Figure 99 shows a bar disintegrator. The cages slid apart for inspection revolve inside each other in opposite directions, and pound the clay to pieces from pure impact. This crusher is used almost exclusively in the dry press process, where the loess or fine alluvial clay is used. The speed of this machine is often as high as 10000 R. P. M. and in general it may be said that the higher the speed the more effective is the work, but at very high velocities the wear becomes ex-



High Speed Sectional Roll Disintegrator

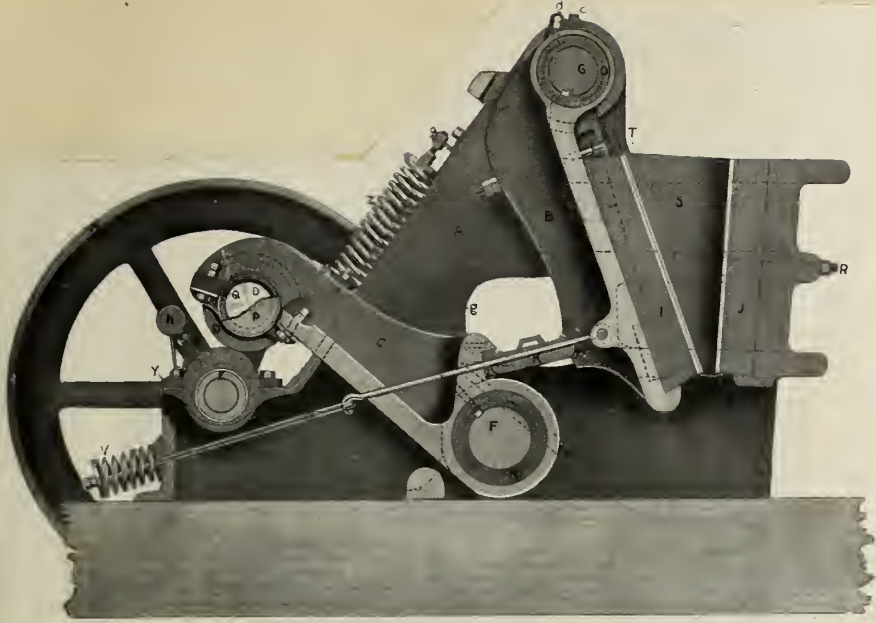
INSIDE VIEW

Fig.96.

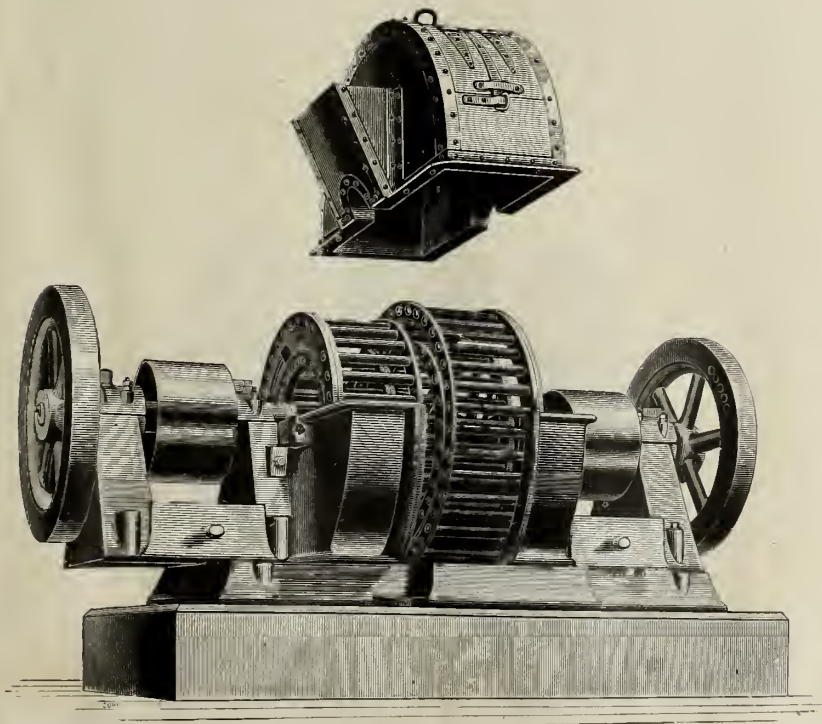


Sectional View of the Potts Disintegrator

Fig. 97.



Jaw Crusher
Fig. 98.



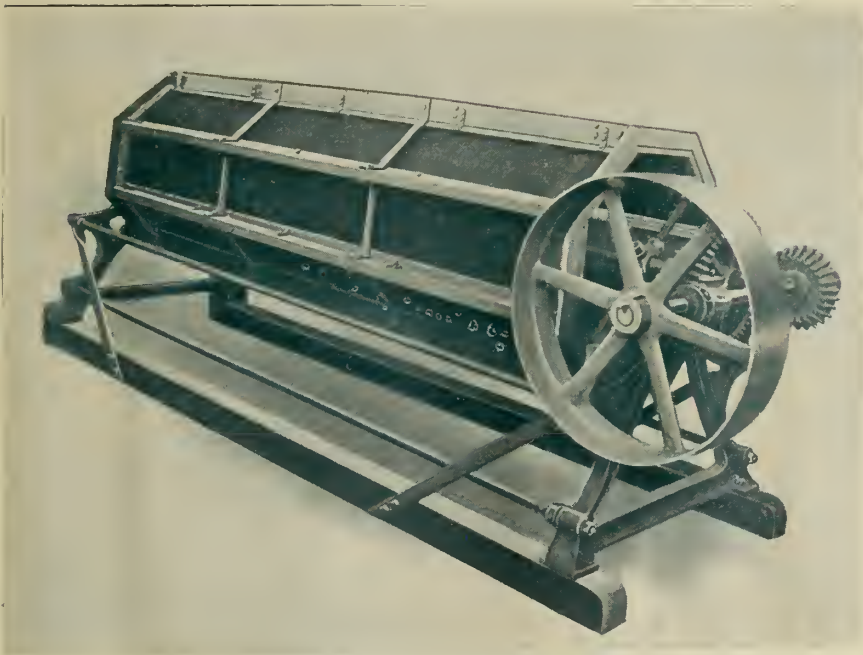
Bar Disintegrator
Fig. 99.

cessive, and necessitates a speed of 3000 to 6000 R. P. M.

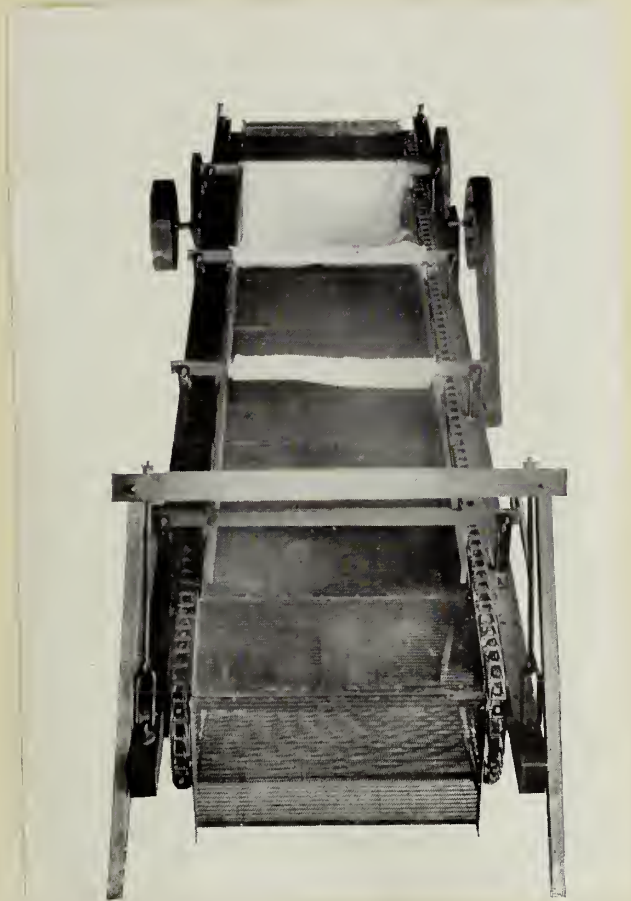
In many cases the pieces of shale as they come in from the bank are too large to be crushed to advantage in the dry-pan. In such cases the clay is first run through a jaw crusher as shown in figure 98. The application of the power to this machine so as to give a reciprocating motion to the inner jaw is easily seen from the figure.

2. Screens. Perforated metal or woven wire screens have, until quite recently, been almost entirely used by the clay-worker. They have been made into long stationary screens, and circular or hexagonal as shown in figure 100. These circular screens are slightly inclined and are revolved at 50 to 90 R. P. M. Both kinds of the above mentioned screens are satisfactory in most clays as far as their ability to screen is concerned, but because of excessive surface required, and high cost of repairs due to a great deal of wear they are now being replaced largely by the piano wire screen. The piano wire screen in figure 104 has no cross wires or anything to impede the travel of the grains along the wires, and has no motion. The usual length for the piano wire screen is 5 feet of screening surface. The wires are held at the ends by pins of much the same design as used in the piano.

In some soft mud brick plants, where there are no stones under say $1\frac{1}{2}$ ", the soft mud screen shown in figure 105 is used. This screen is hard to work satisfactorily because of the difficulty of tempering the entering clay to the proper consistancy, and keeping the screen free of foreign material.



Revolving Screen.
Fig. 100.



Dunlap Perforated-Metal Screen
Fig.101.

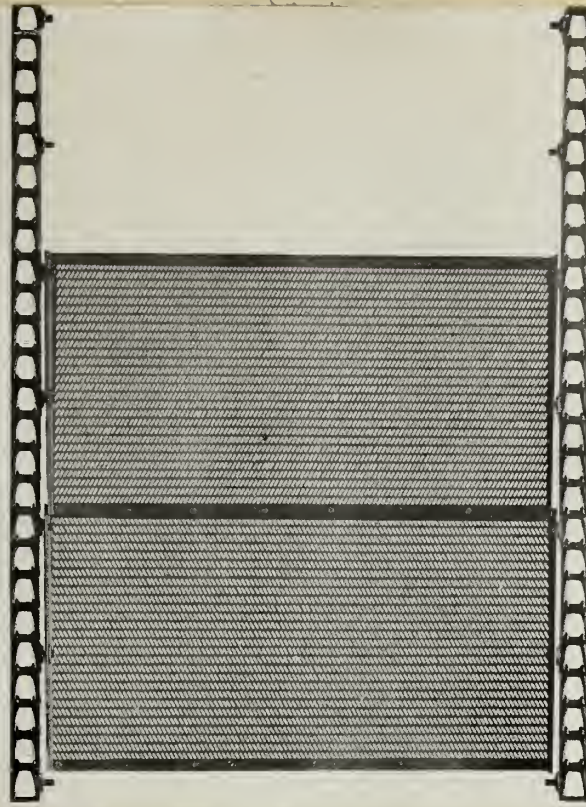
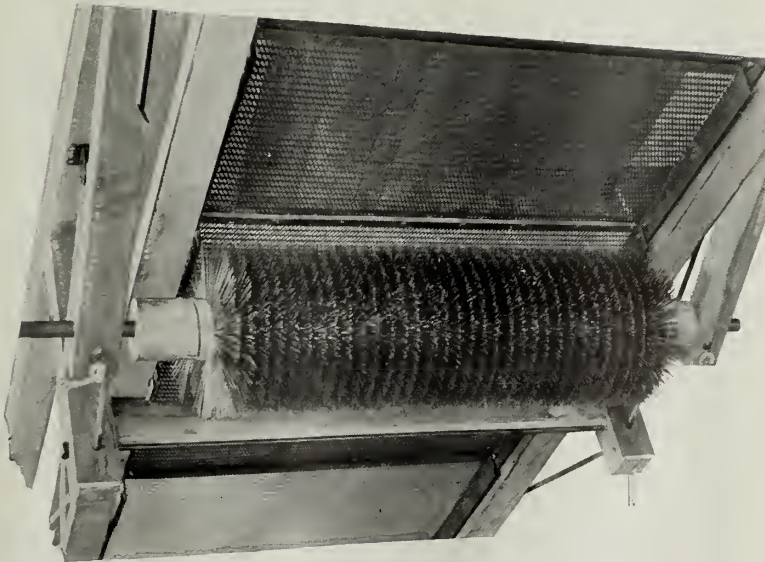
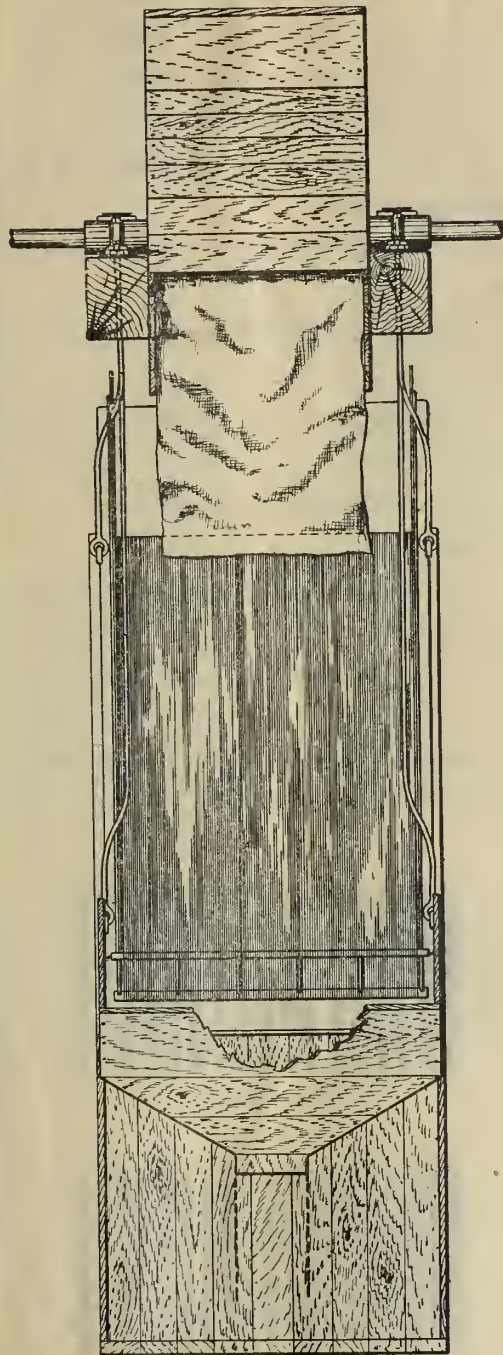


Fig. 102.

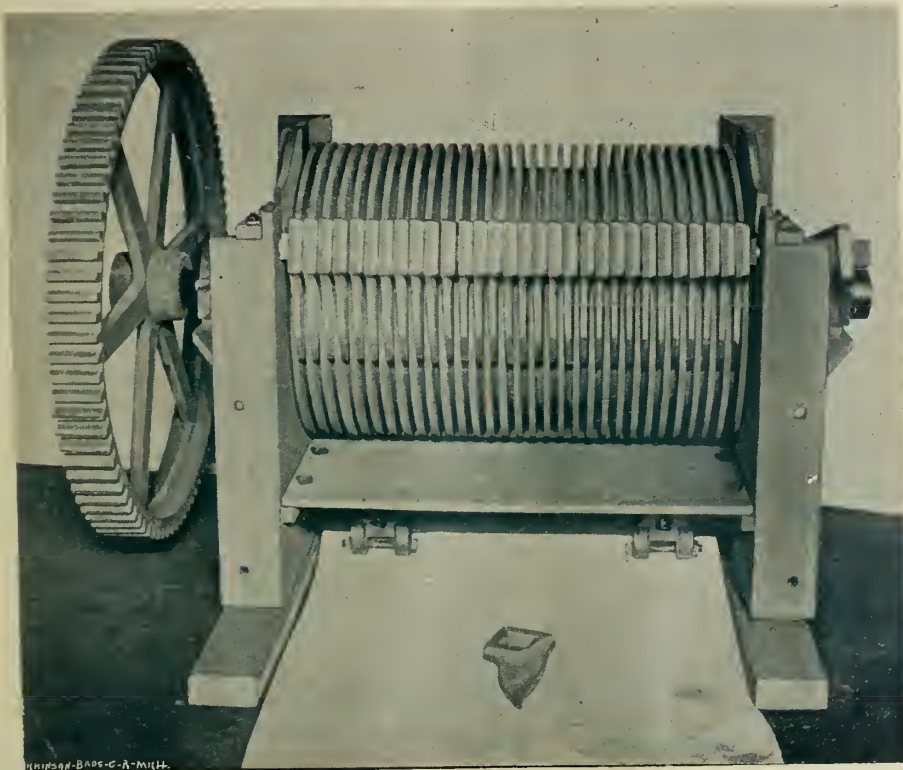


This is an enlarged view showing the brush as it comes
in contact with the clay side of
the plates.

Details of Dunlap Screen Fig 103

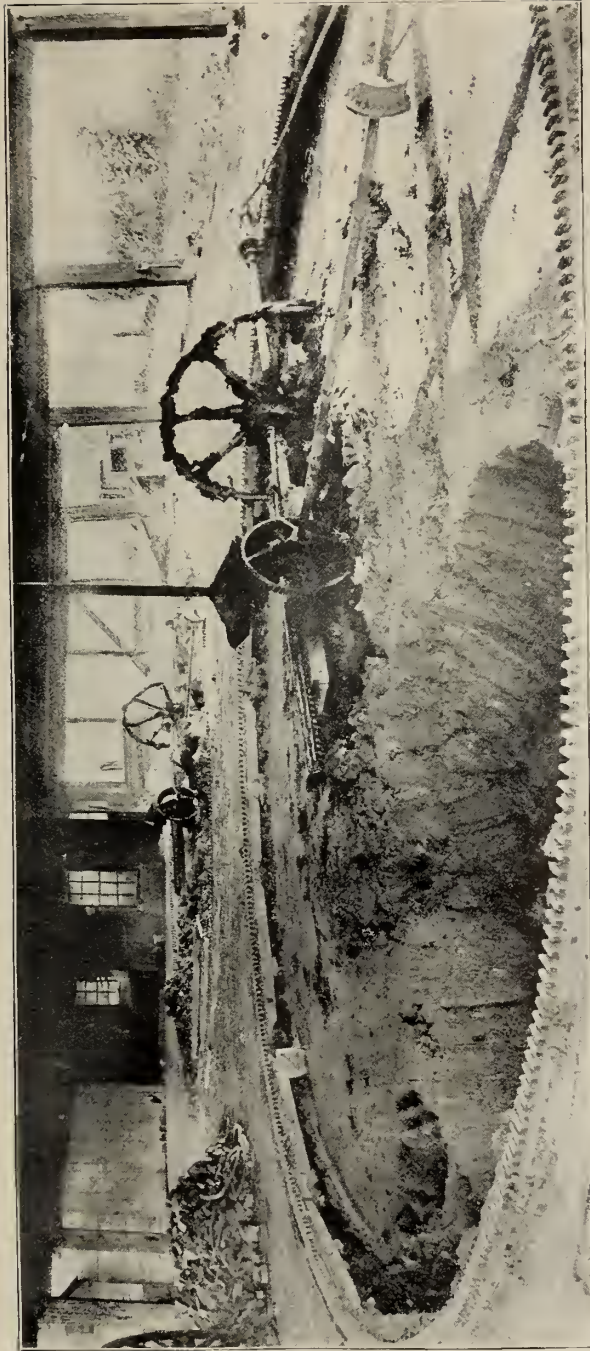


Piano Wire Screen
Fig. 104



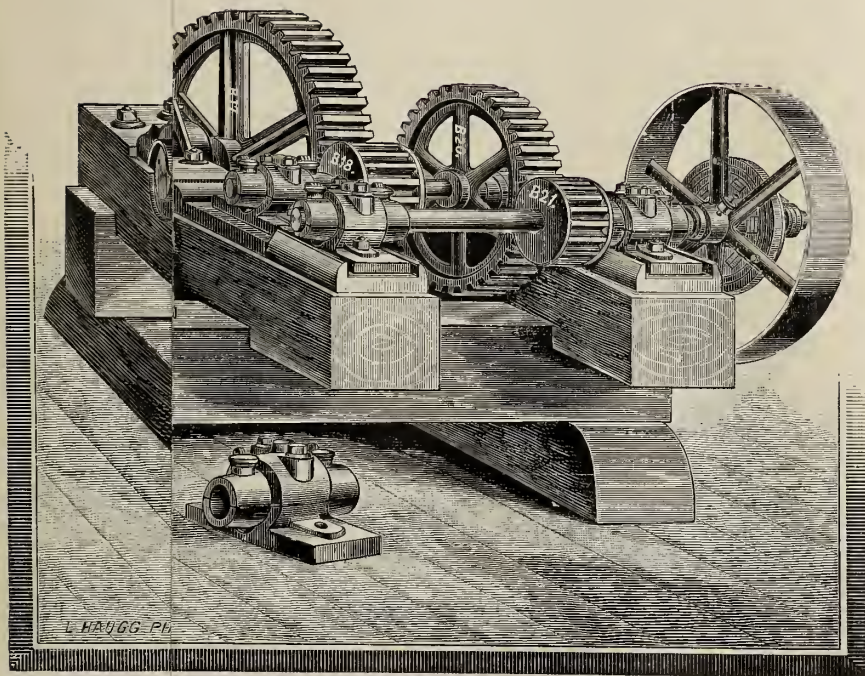
Soft Mud Clay Screen
Fig. 105.

3. Pugmills and Granulators. A thorough mixing of all clay used in the manufacture of clay wares is absolutely necessary if a good product is to be the result. This is accomplished by the pugmill in most cases. However, in only the last 35 years has this machine been so widely used for mixing. The tempering wheel as shown in figure 106 was used up to the time of the introduction of the pugmill exclusively. This machine is now rarely used in plants. The pugmill shown in figure 107 is constructed upon the same principle that all of our up-to-date pugmills are now being manufactured. The power is transmitted through two sets of gears in most cases so that the pugger shaft is revolved quite slowly (40 to 90 R. P. M.). The dust and small grains enter the gear end of the machine, and are mixed with water in correct proportions, so that the result of the mixing is a stiff mud at the delivery end. The knives are set at such an angle that the clay is both mixed and pushed forward. The end thrust of the pugger shaft caused by the reaction of the moving clay upon the knives is taken up by step bearing at the gear end. These step bearings are in most cases made up of alternating steel and bronze disks running in oil, but in a few cases are composed of rings shrunk on turned on the shaft which run in a babbitted boxing. The granulator is a machine built on exactly the same principle with heavier parts because of the service it is put to. This machine receives the clay directly from the car in car-load lots (2 to 3 yard cars) as it is hauled from the pit.



Photographic view of a Ring-Pit Tempering Wheel for grinding clay for moulding by hand. A process of brickmaking that is being gradually forced out of use.

Fig. 106.

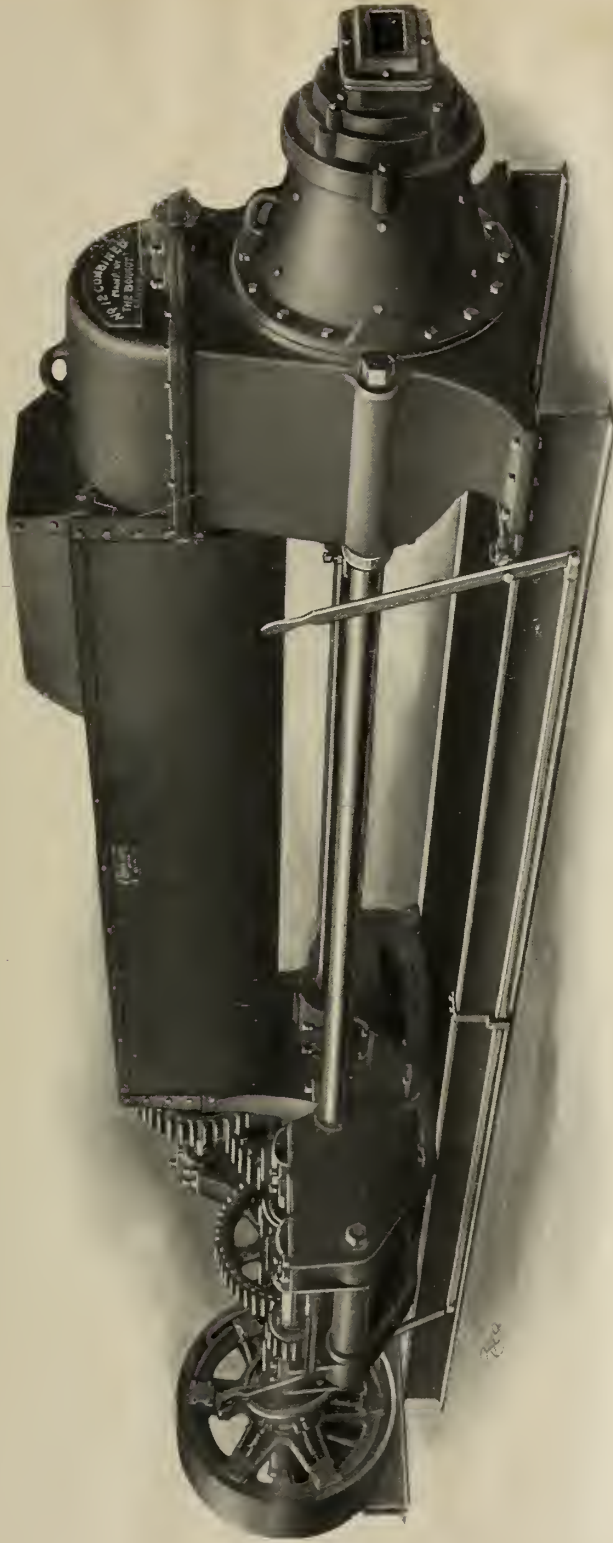


Pug mill.
Fig. 107.

This machine receives no water, and, therefore, does not produce plasticity in the clay, but breaks it up into small grains about the size of a pea. The clay when thus broken up, and feed to a set of rolls is more thoroughly mixed in the pug-mill. The machine also acts as a feeder to the rolls, because, even if car load lots are delivered to the machine at one end, the other end delivers a constant quantity to the rolls. Very few shales are used in plants using such a machine. The only cases in which shales have been used to the knowledge of the writer is after a hard shale has been weathered, or a Devonian shale which is generally quite soft is found.

The latest developments along the line of pugging the clay have been in combined pugging and moulding machines. Figures 108 and 109 show machines of very late design in which a saving of room and power is affected. In figure 109 it will be noticed that the head of the machine, or drum as it is more frequently called, is removed for inspection of the method of arranging the augers.

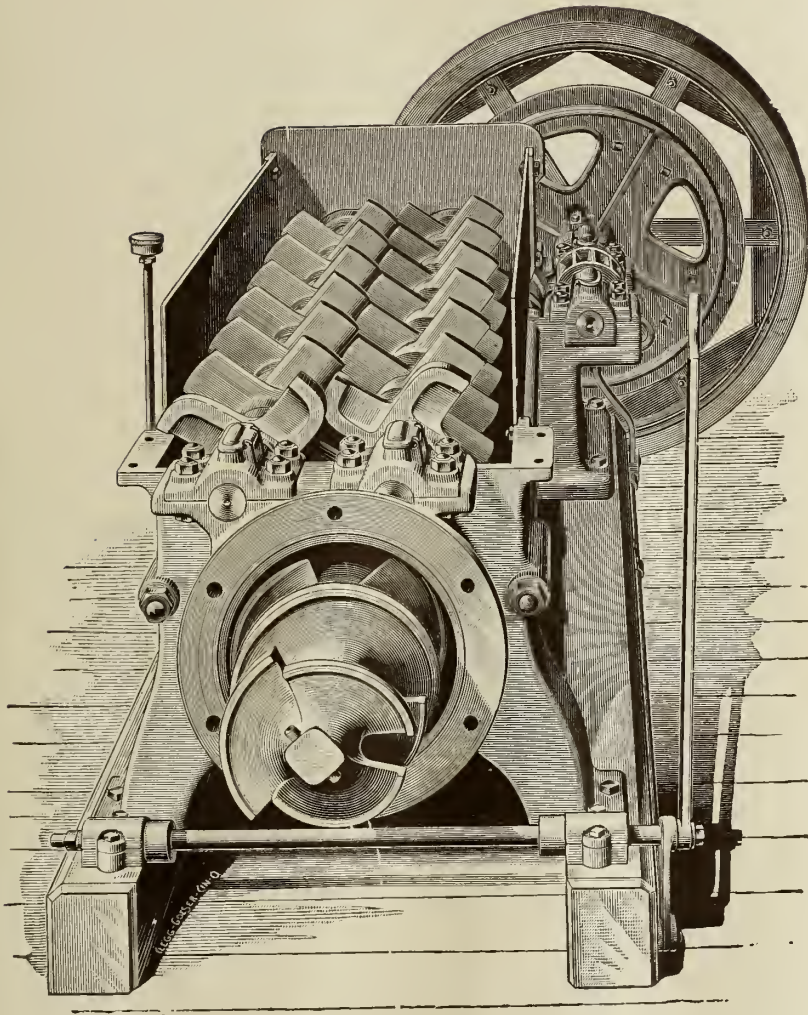
In figure 110 is shown the type of a mixer used in the dry press process. This pan is kept about 1/6 full of the dry dust which is agitated by the revolving paddles, and thoroughly mixed before escaping through the hole in the bottom to the press. Any slight difference in quantities of clay coming from the dryer, or pit is evened up, and no noticeable difference in the color of the finished ware may be seen due to this defect in the loading at the pit.



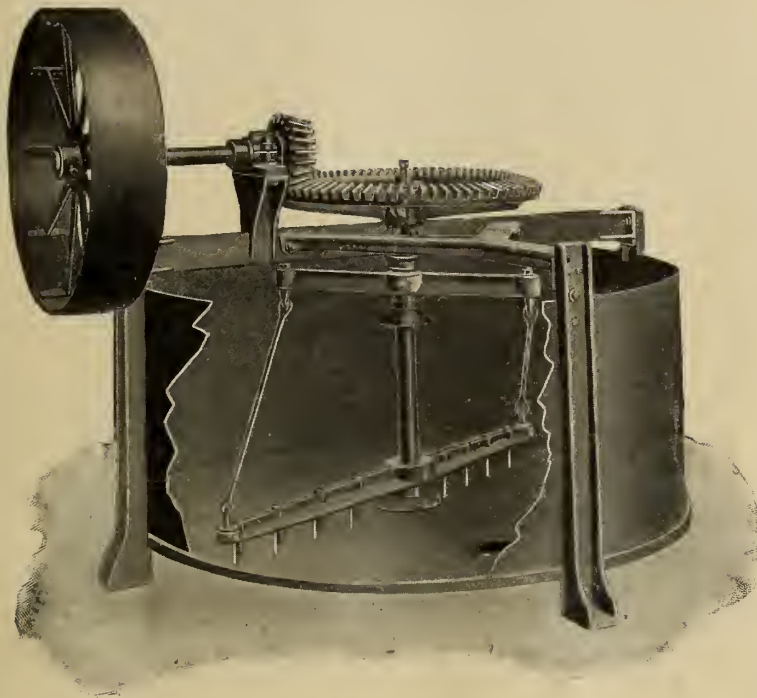
No. 12 Combined Brick Machine and Pug Mill

All gears and pinions of cast steel	Self-contained on steel I beams	Interlocking hubs in Pug Mill
Main shaft rebabbitted without dismantling		Capacity 100,000 to 125,000 brick in ten hours

Fig. 108.



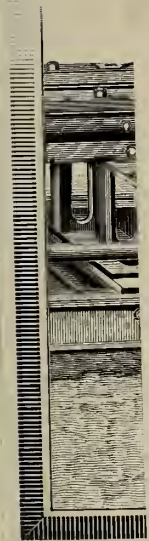
Stiff Mud Combined Brick Machine and Pugmill.
Fig. 109.



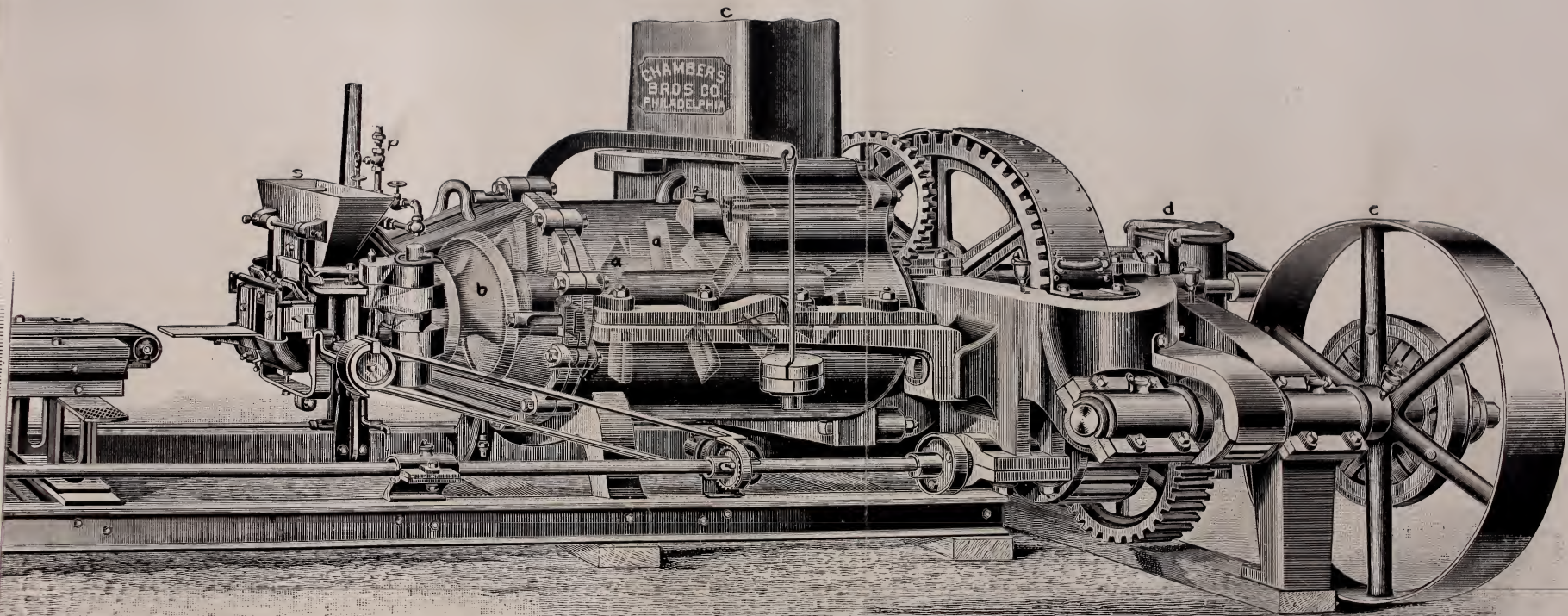
Dry Mixer.
Fig. 110.

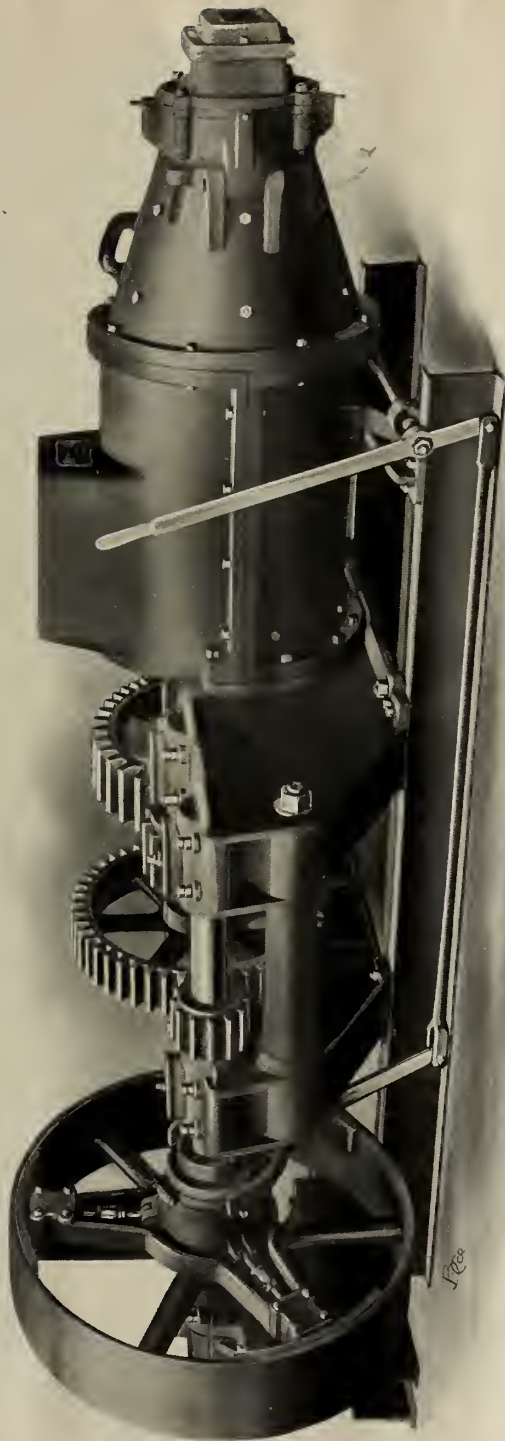
4. Brick and Tile Machines. These machines are divided into two classes. a. The horizontal auger feed is perhaps the most common because of less complicated mechanisms and greater accessibility. The horizontal auger type shown in figure 111 has the pressure feed down the hopper c with a force feed rectangular revolving rod at the bottom of the hopper. The puggers are shown at a, and the augers at b. The die which is situated at the front end of the auger is not clearly shown, but at p is shown the pipe through which steam is forced into the die so that the clay column is lubricated. At s is shown the sand hopper which distributes sand over the four surfaces of the column, and thus prevents sticking on the cars and cutting table. The thrust of the clay upon the augers and puggers is taken up by step bearings in the back of the machine. This is shown at d. The main shaft is rotated through a set of gears by the pulley which is belted to the line shaft of the factory. The speed of the pulley shaft is generally from 300 to 400 R. F. M. A friction clutch, such as is used on most of the machines used in the clay working industry, is shown on this machine. These clutches are nearly all of the expanding paper or wooden faced type. Figure 112 shows another make of machine.

b. The vertical feed auger machine as shown in figure 113 takes advantage of the force of gravity in producing a more positive feed to the moulding auger. This machine will stand speeding beyond its rated capacity, because the clay can-



Stiff Mud Brick Machine
Fig.III.



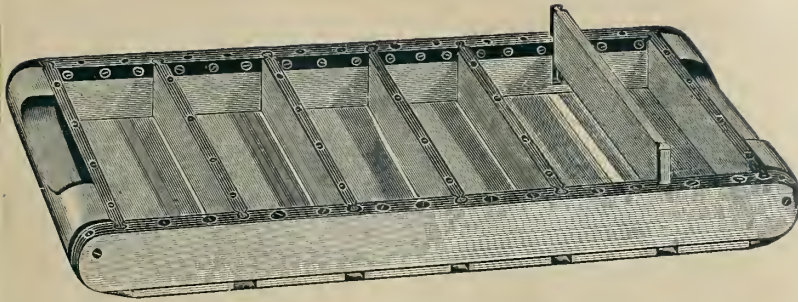


No. 10 Auger Brick Machine

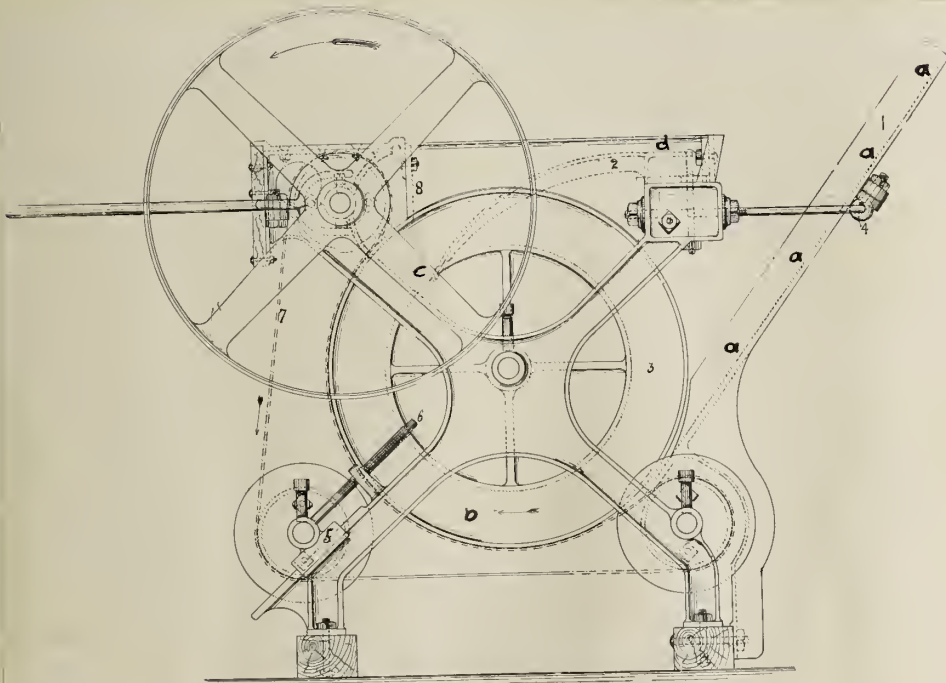
Fig. 112.

not back up as in the horizontal types. This machine is especially adapted to soapy clays which tend to laminate. The constructive features are similar in principle to those of the other type.

Figure 114 shows a side view of a soft mud brick machine. This machine is quite different in its construction from those of the stiff mud process. The pugmill of this machine is always in combination with the moulding apparatus, because of the more positive feed of a very soft clay, thereby secured. The clay is worked forward by puggers set at a much larger angle to a plane of revolution than in the stiff mud machinery. The clay upon reaching the front of the machine is pressed downward, and into the plunger box through a. The plunger then descends, and presses the soft clay into the mould boxes as shown in figure 115. As the ram is withdrawn the surface of the box is "struck", and the moulded brick pushed out on the table. The brick are now taken from the mould, and laid on palates by turning the moulds over. In order that the brick will not stick too tightly in the mould, sanding of the damp moulds is resorted to. This is done in such a machine as shown in figure 116. In this sanding machine, the moulds are laid in the hopper at a, and are carried around by the belt b, and delivered at c and d to await another charge of mud. It will be seen from the drawing that as long as two or three moulds are in the machine one will be kept on the delivery table d. The bottom of the machine is kept partly full of sand so that each mould is completely immersed as it passes. Figures 117 and 118 show two

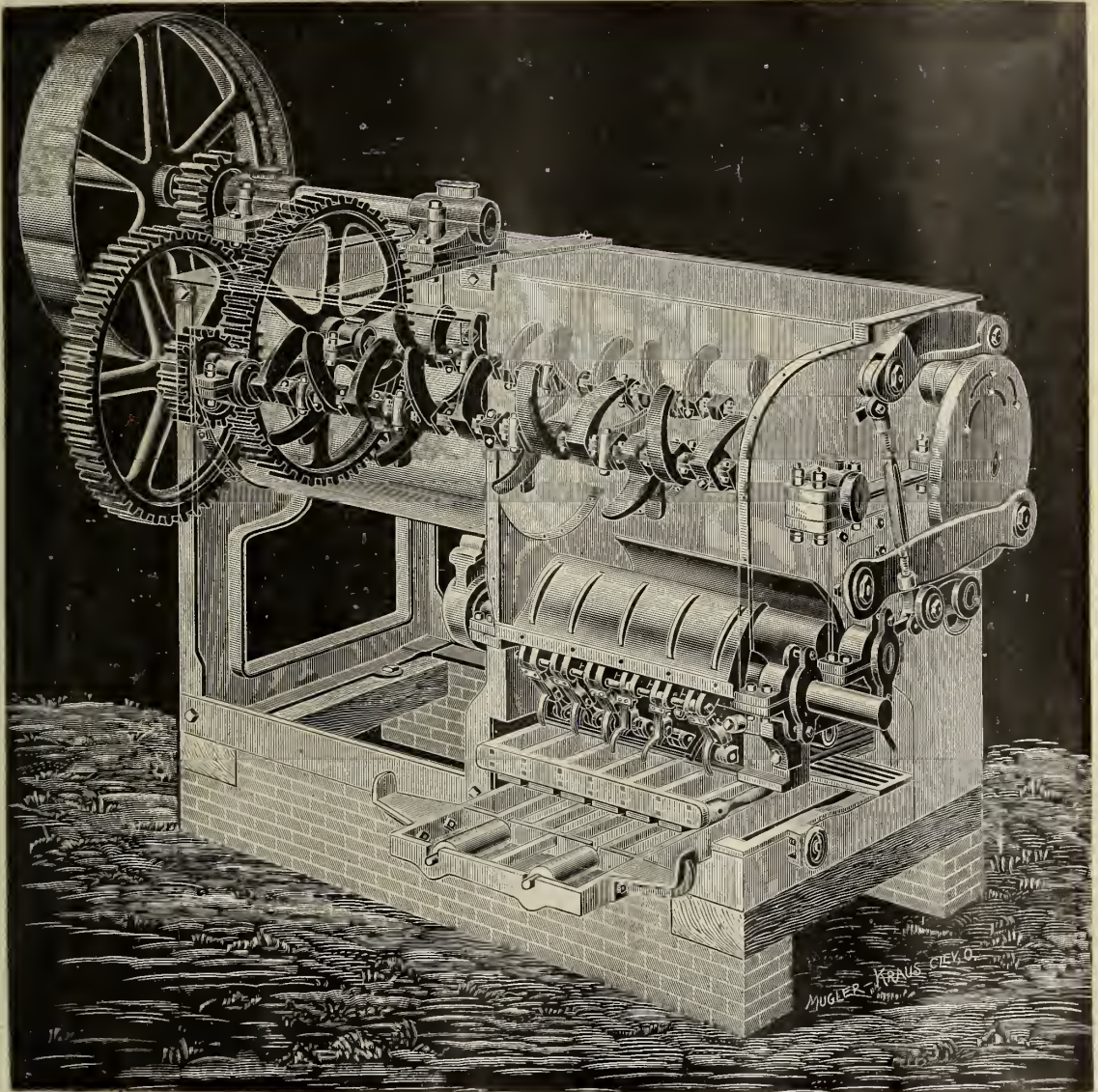


Soft Mud Mould Box.
Fig. 115.

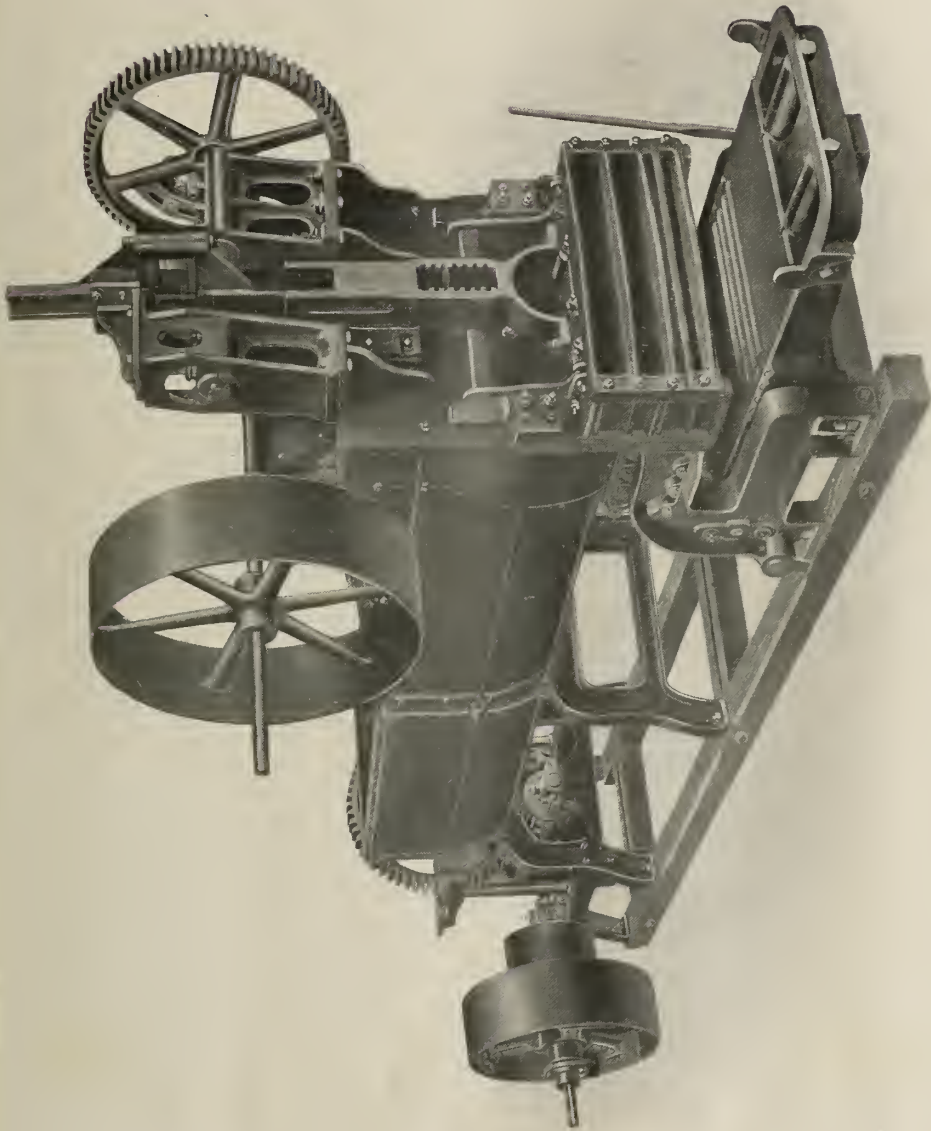


PATENTED FEBRUARY 5, 1889

Mould Sander
Fig. 116.



Soft Mud Brick Machine.
Fig. 117.



The Potts Horizontal Stock Brick Machine

Fig. 118.

representative types of the side and front delivery soft mud machines.

5. Cutting Tables. Many types of cutting tables have been designed in order that difficulties meet with in some of the earlier ones might be overcome, and the result has been several excellent tables all of different mechanical construction. The type has changed from the old style hand operated as shown in figure 119 with board delivery for brick. This table is operated by the lever at a, and delivers several brick upon a board resting on the arms at b. Tile tables were also built upon the hand lever cutting principle, but have long ago become obsolete except in some yards which are 20 to 30 years behind the times.

The table shown in figure 120 is automatic, and is operated by a series of gears and excentrics in such a manner that the wires always cut over and down as shown in figure 121. Good smooth corners are always obtained if this method of cutting the column is used.

The table shown in figure 122 of Bensing patent is also an automatic. In this the reel a is mounted with no positive connection to the other moving parts. The guides g in moving with the clay column from the machine strikes the reel arms, and carry them along. The wires stretched across the ends of the arms as shown in the figure are thus forced through the clay, and back again by the same path as the arms start to rise again. This table requires little power, and is

Board Delivery Cutting Table

Weight 1,300 pounds.

Capacity 2,000 to 3,000
per hour.

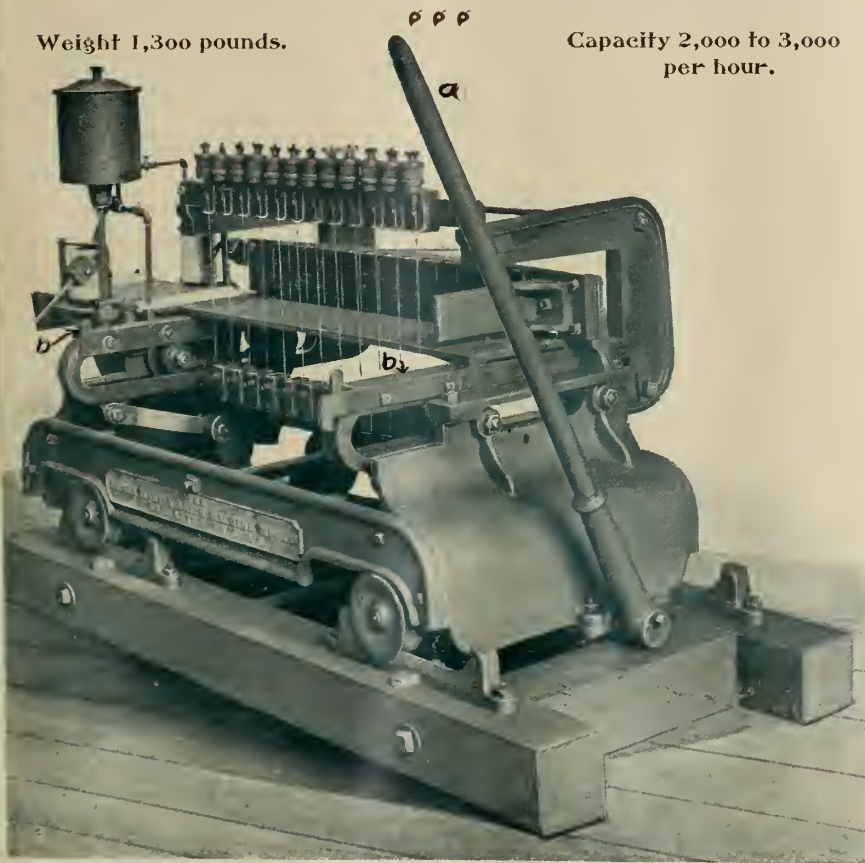
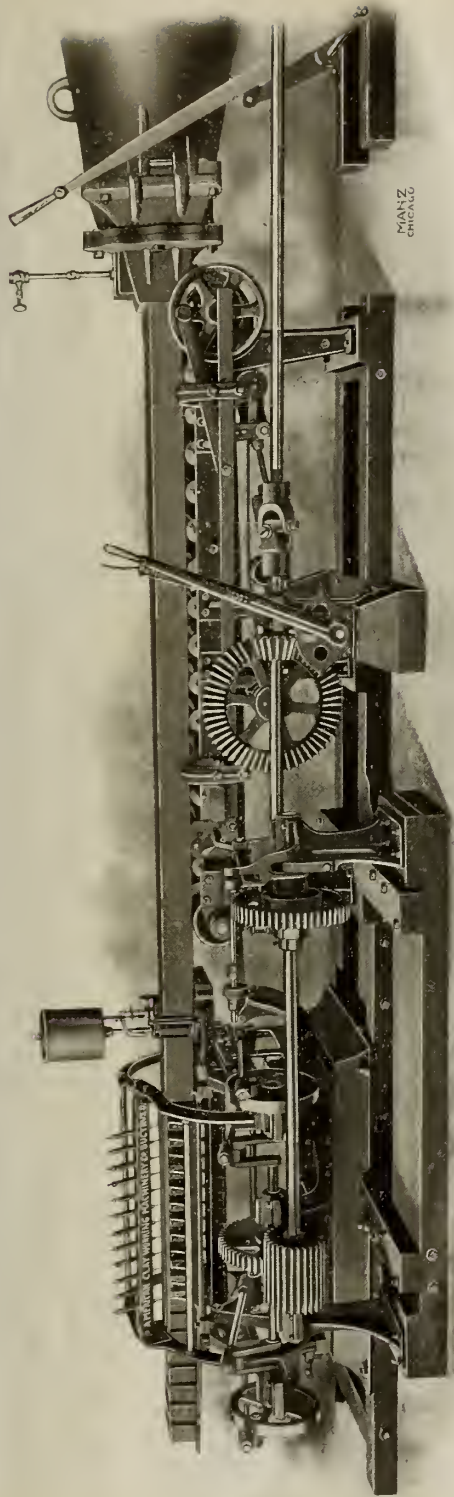
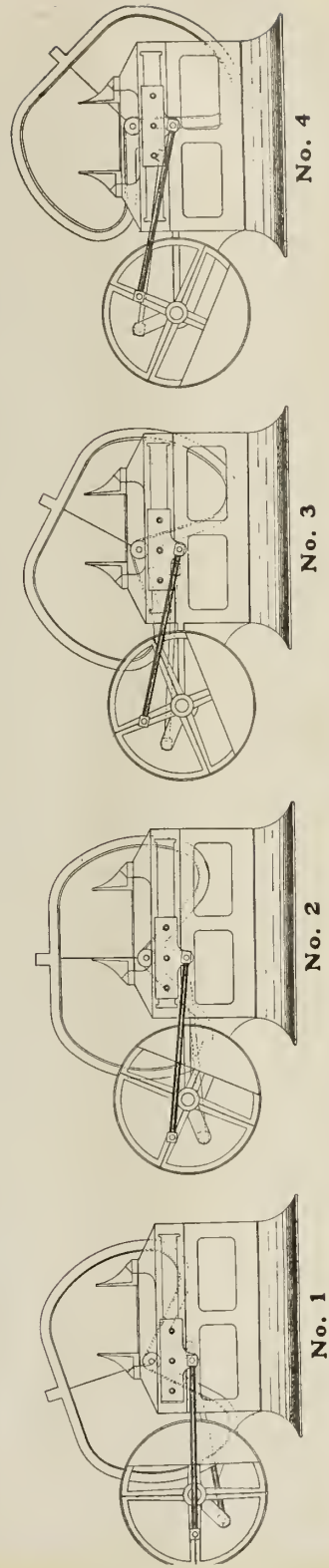


Fig. 119.



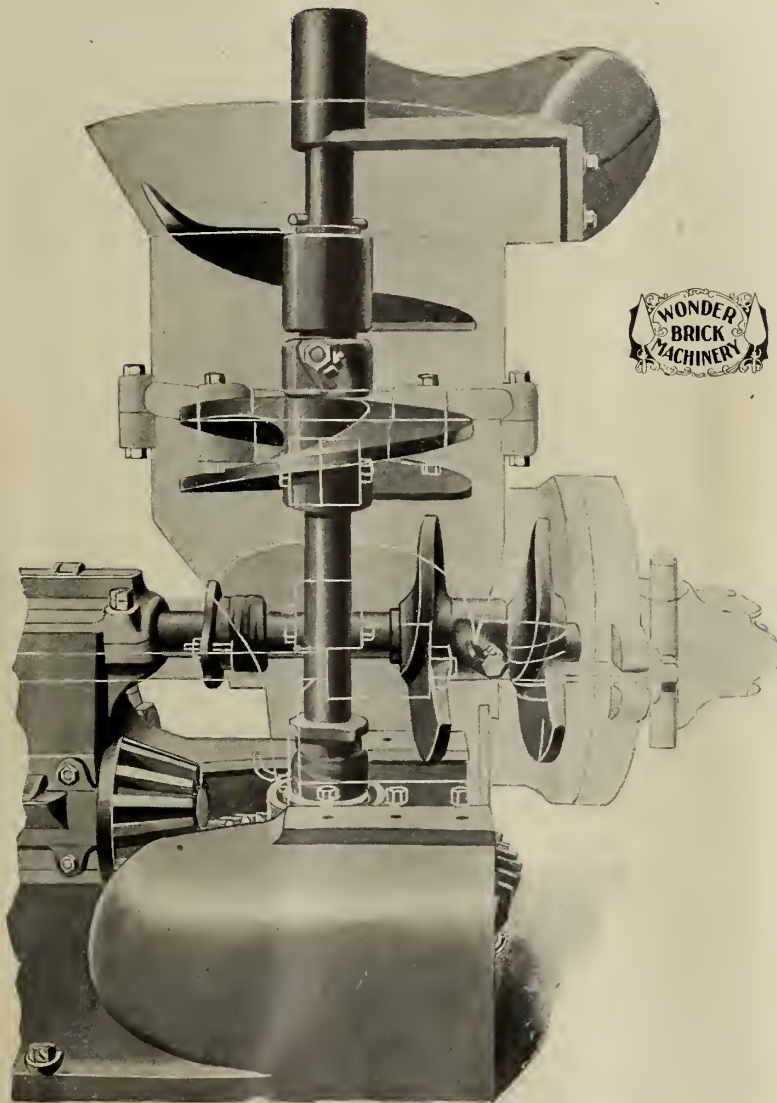
Cutting Table.
Fig. 120.

Diagram Showing Oscillating Movement of Cutting Table

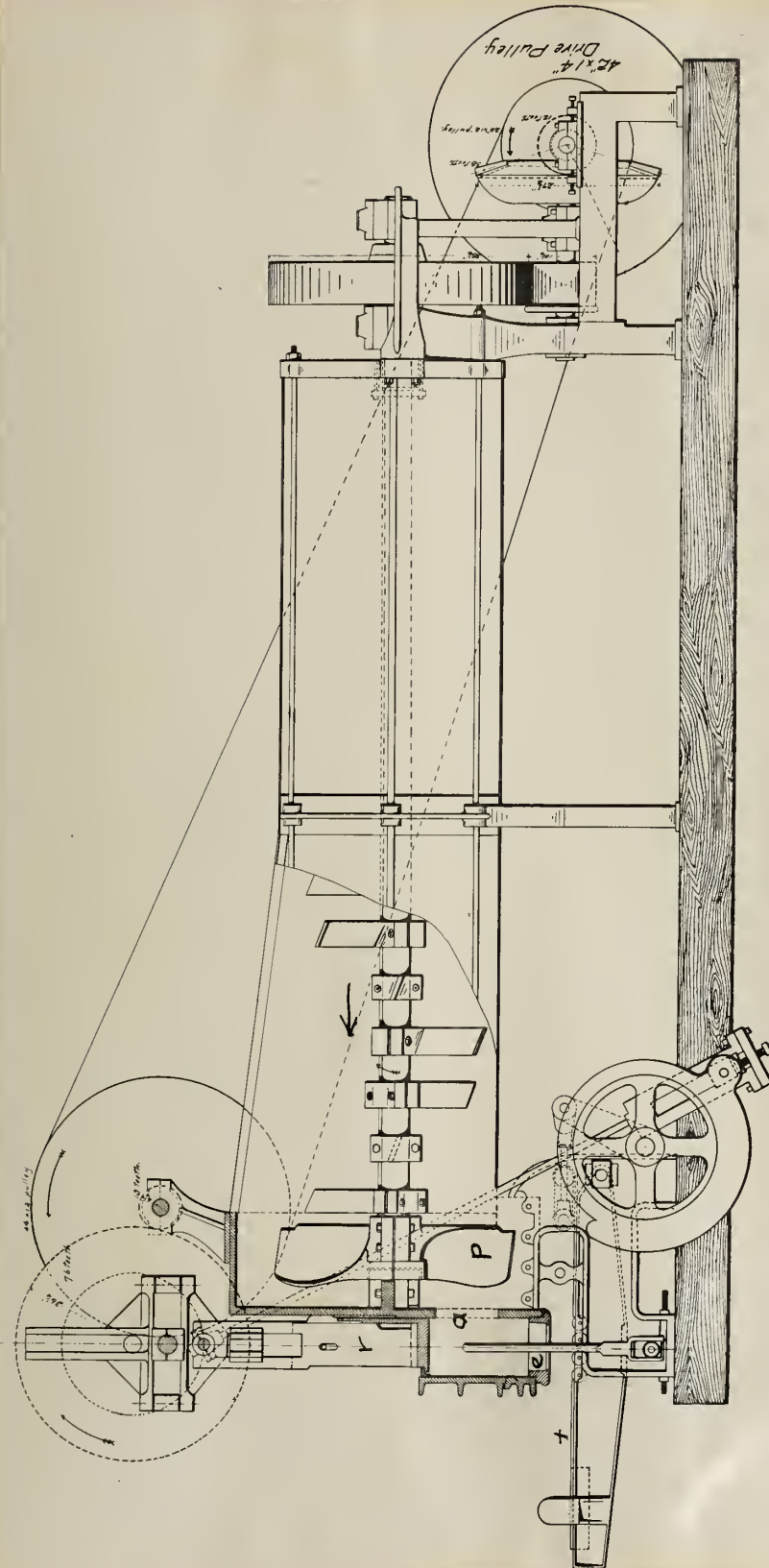


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Fig. 121.

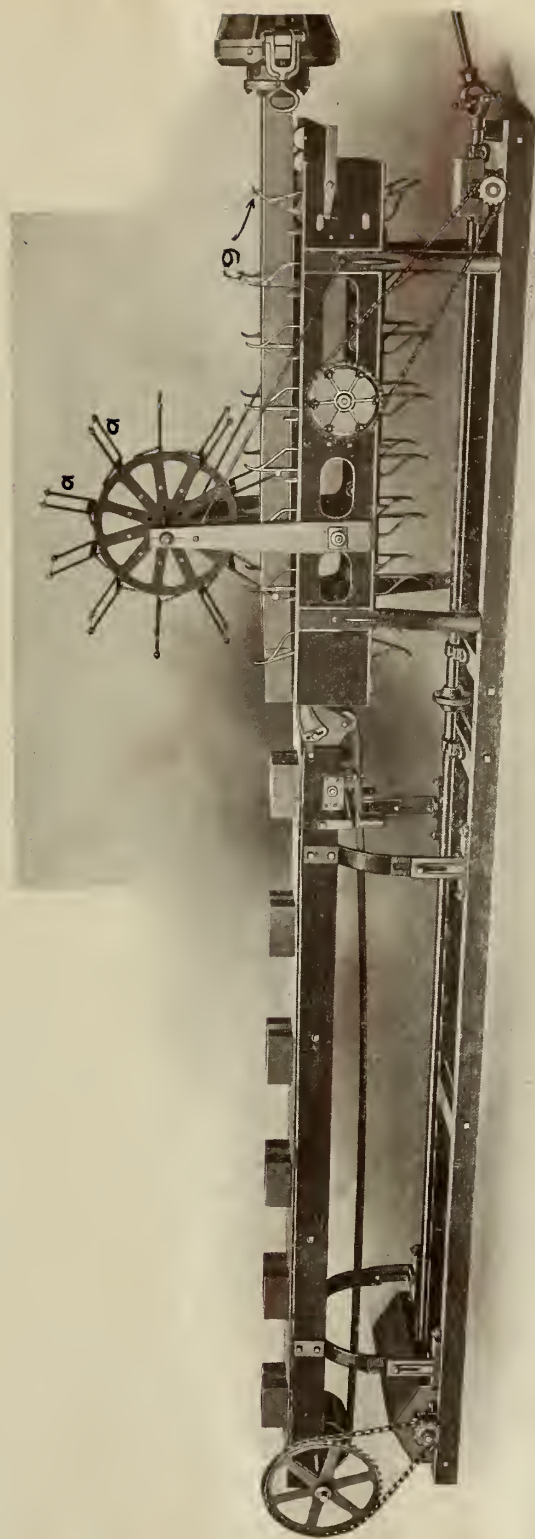


Stiff Mud Brick Machine
Fig. 113.



Sectional View of the Potts All Iron Horizontal Brick Machine

Fig. 114.



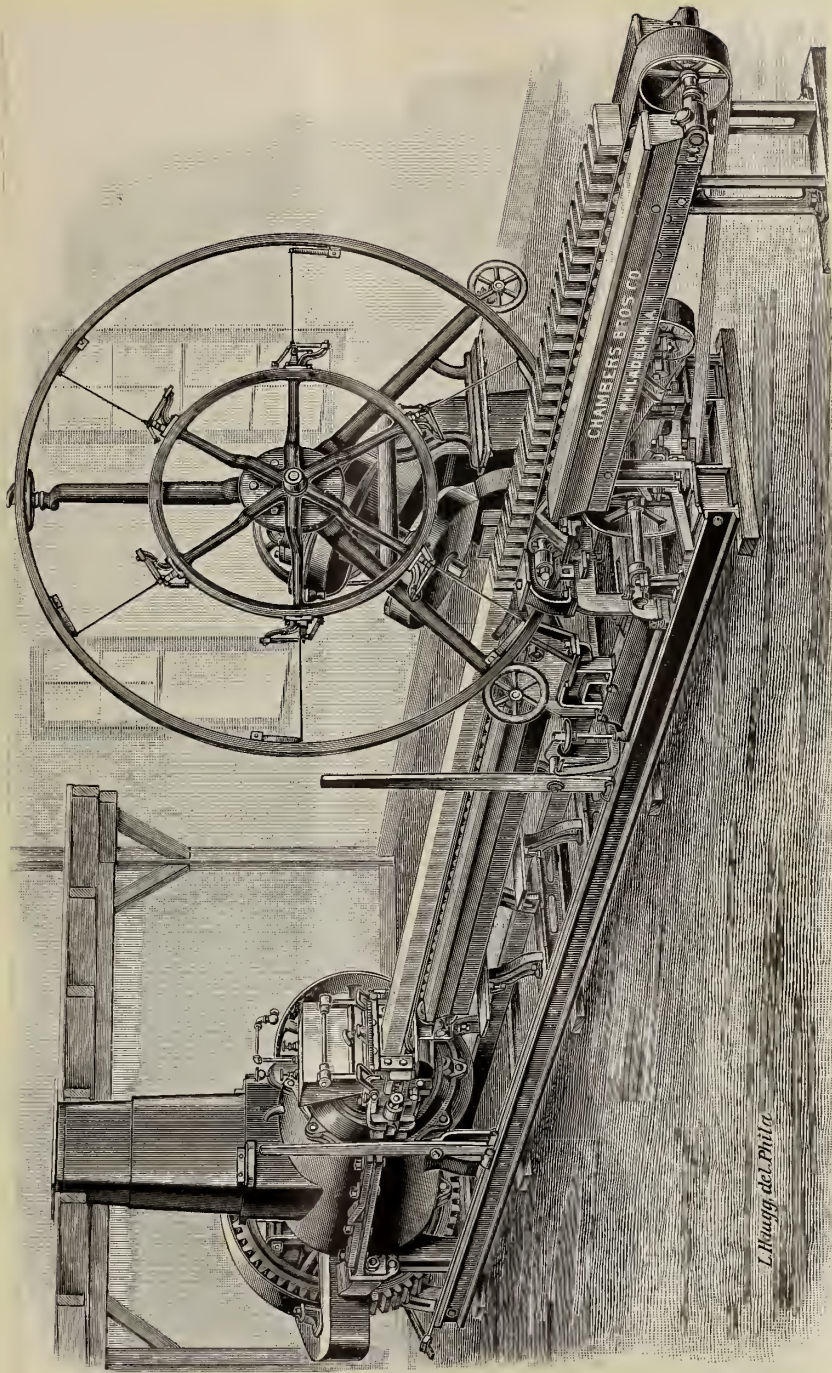
Bensinger Cutting Table
Fig. 122.

very simple. In tile cutting no other forces than those exerted on the table by the moving column is friction as it lies in its trough is required.

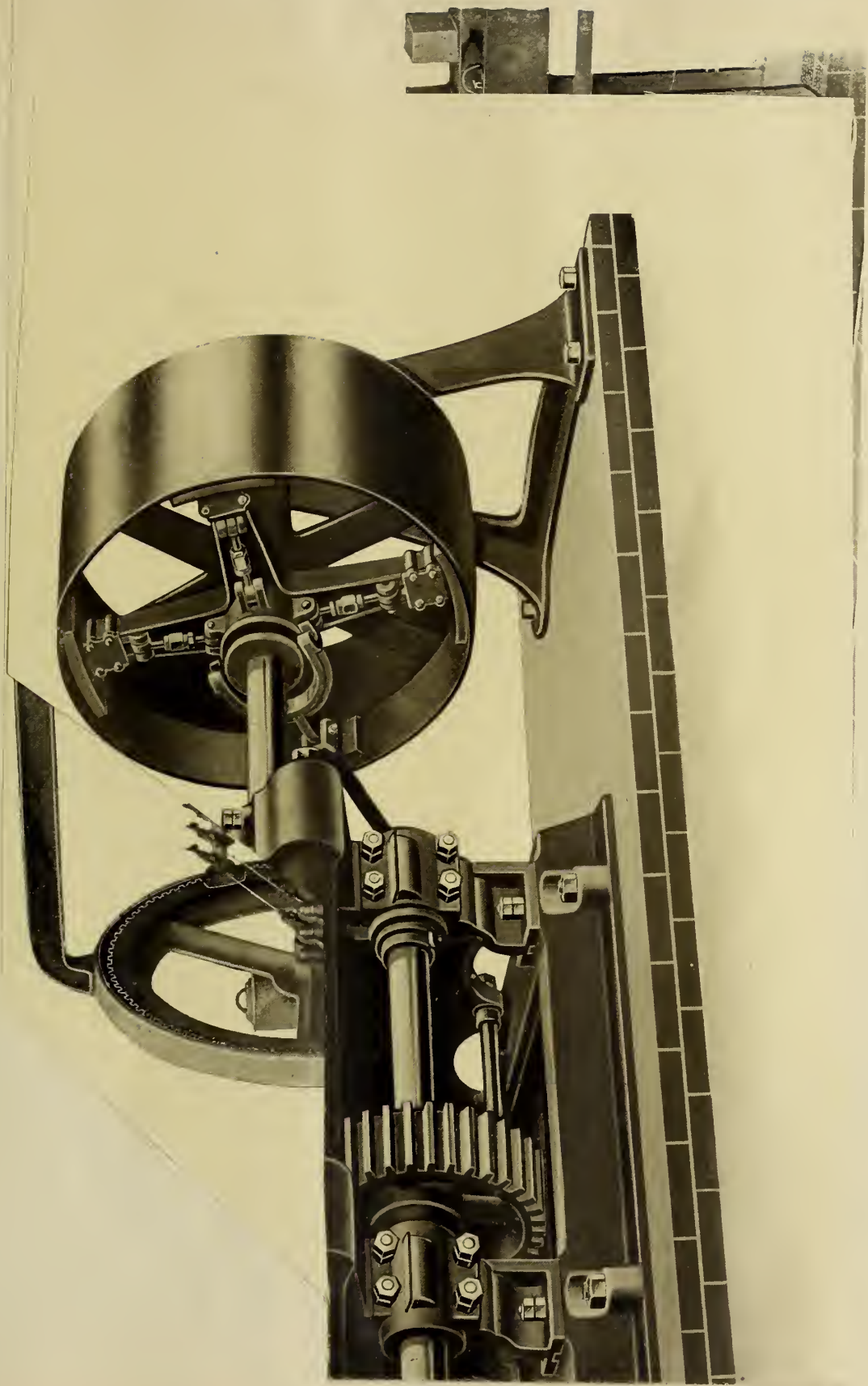
Another table patented at about the same time is that shown in figure 123. In this machine, the cutting wheel is mounted at an angle to a plane of revolution of the moving column. The wheel is revolved so that the distance in the direction of the moving column advanced by the wire is the same as that moved by the column while being cut. Thus a rectangular brick is formed by a rather simple cutting mechanism.

Later tables are shown in figures 124 and 125 while a modification of the original Bensing patent for tile cutting may be seen in figure 126. Figure 127 shows still another modification of the Bensing patent for side cut brick. The cutter shown in figures 128 and 129 is a late patent, and is an novel arrangement of simple and compact mechanisms. By means of gears and cams the velocity of travel of the wire in cutting is the same as that of the moving column. Because of the lightness and positive cut this cutter will handle over 500 brick per minute. The indenter described in connection with the Springfield Paving Brick Company's works is most successfully used in connection with this cutter.

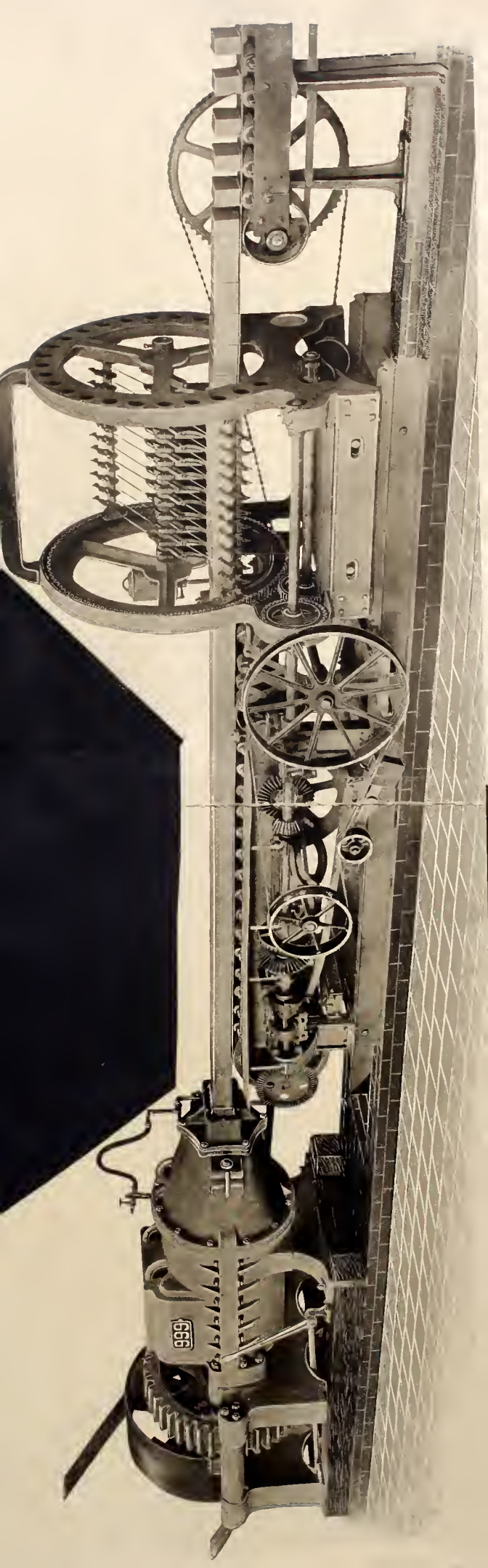
6. Presses. Tile larger than 18" have not been made successfully on a horizontal machine because of the difficulty of making them stiff enough to lay upon their side even when supported one-half the way up each side as in the table shown



Chamber's Cutting Table.
Fig 123.



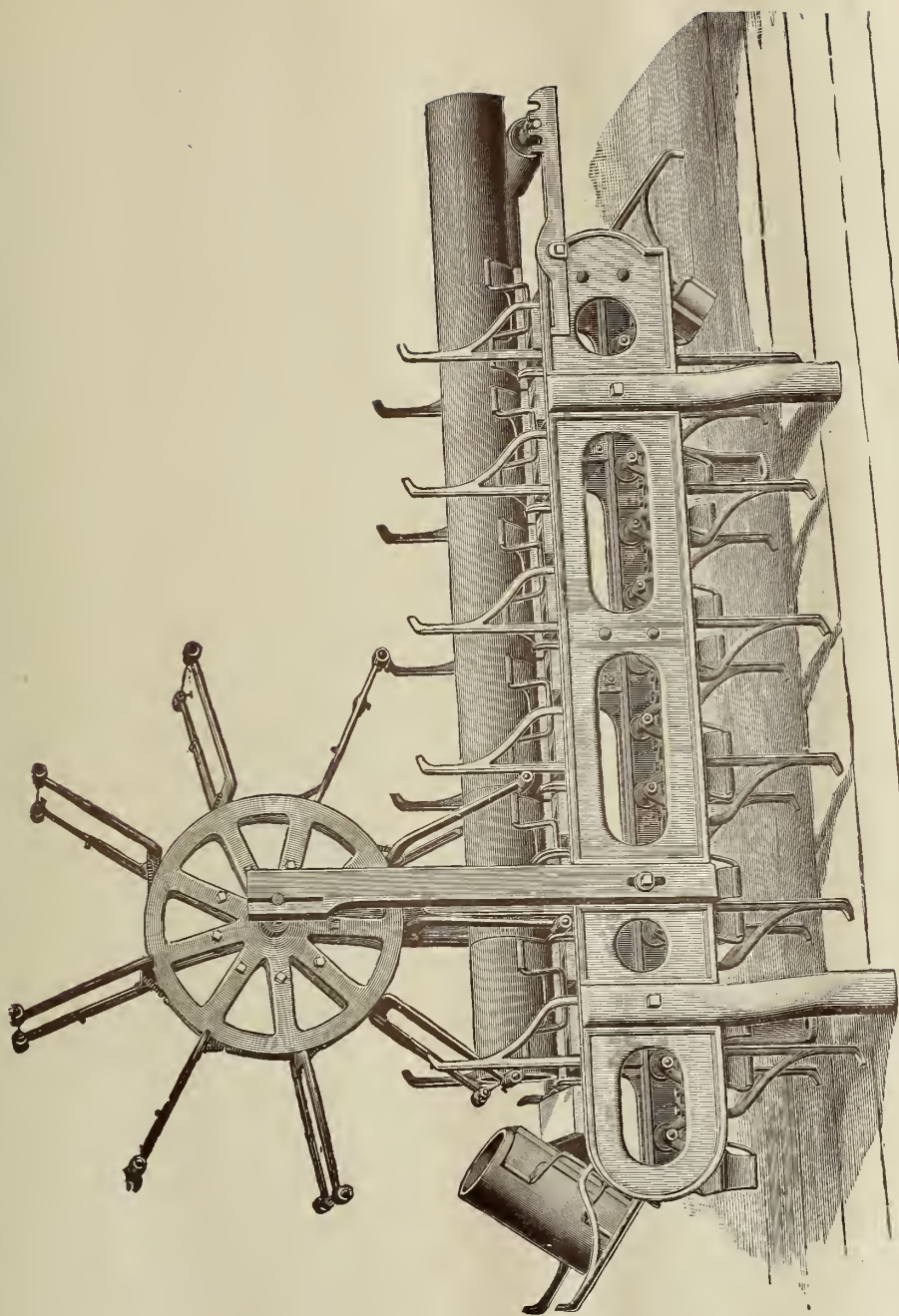
Chamber's Cutting Table
Fig. 124.





Automatic Side Cut Table

Fig. 125.



Bensing Tile Table
Fig. 126.

Automatic Side

Cutting Table

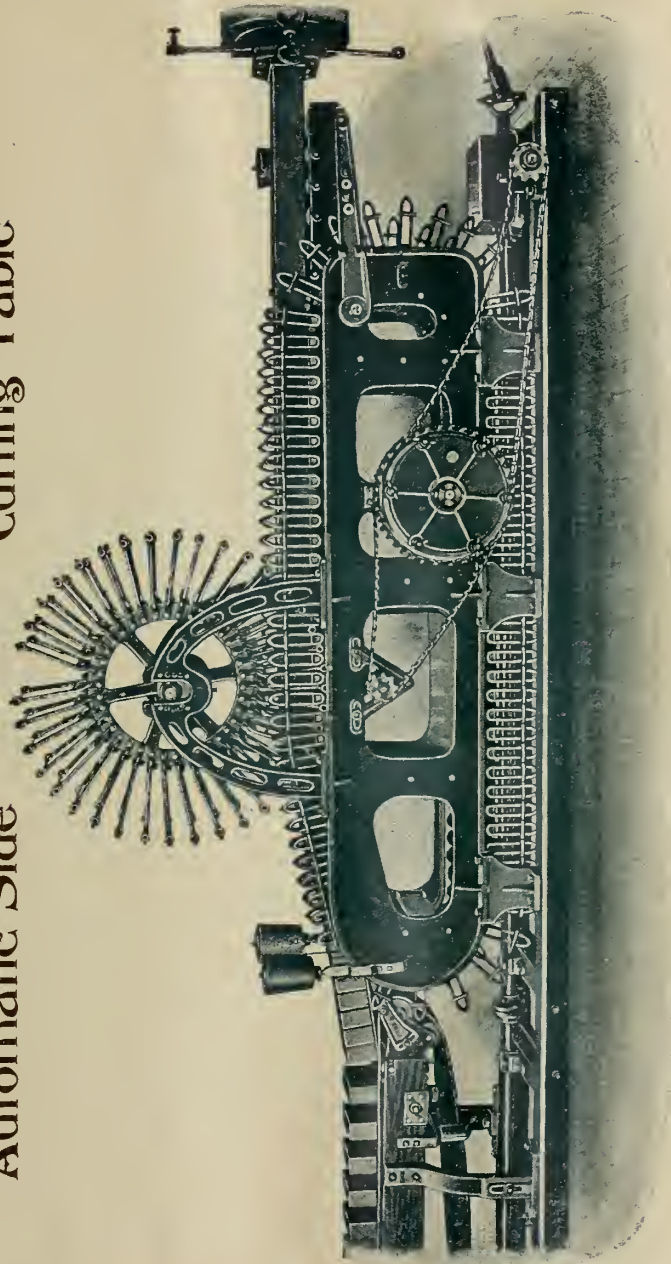


Fig. 127.

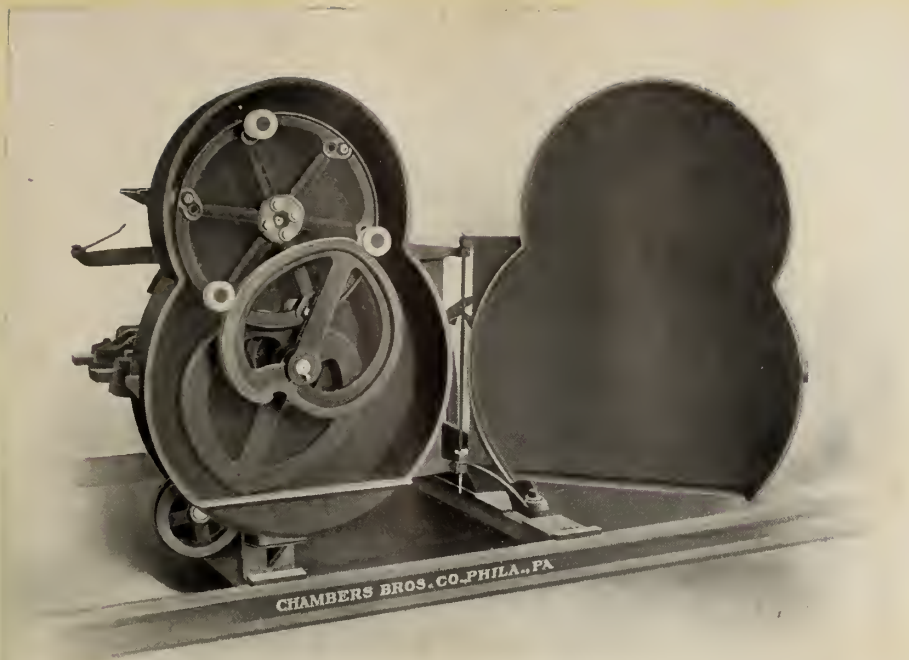
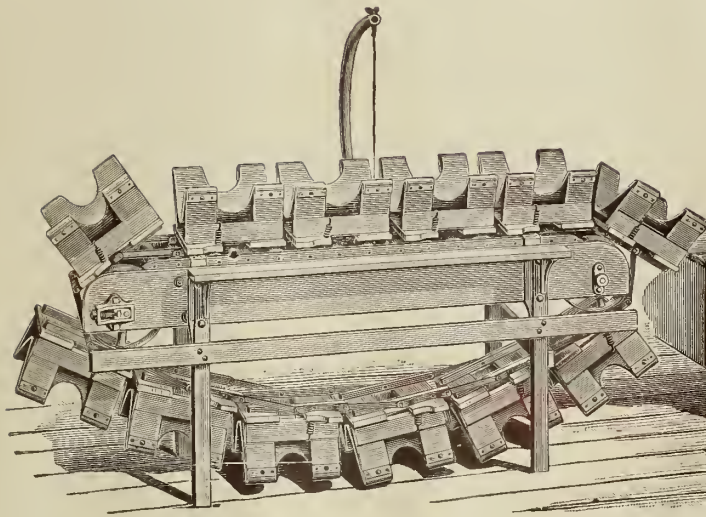


Fig. 128.



Chamber's Cutter. Fig. 129.



Hand Cutting Table.
Fig. 130.

in figure 130. The pipe press has therefore been designed with the idea of over coming this difficulty, and, at the same time, moulding a flange such as is required in sewer pipe work. It is because of this flange alone that sewer pipe smaller than 12 inches in diameter are made on the press. The smaller pipe are made several at a time depending upon their size. For example in the manufacture of 3 inch pipe often as many as six at a time are pressed.

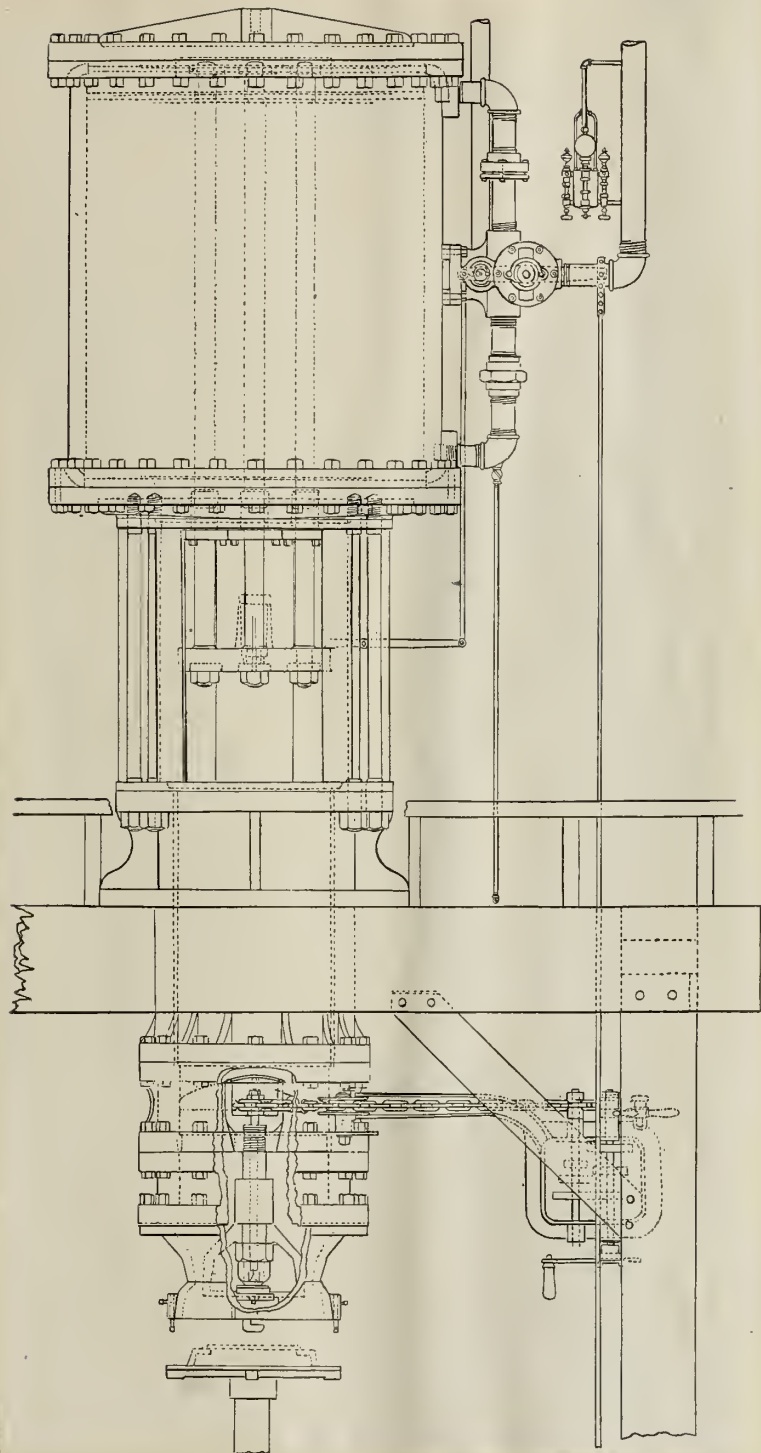
In the press shown in figure 131 the plunger at a is lifted by a steam piston at c and the cylinder b is filled with the plastic clay. The ram r is then brought up to a position so that the lower end of b is closed, and locked by turning l with the compressed air cylinder shown at m. The steam pressure is then turned on in c, and the clay forced out into the flange space. The lever d is then unlocked, and the pipe is run out the desired length by control of the steam piston, when it is cut or broken off. Some machines have an internal cutting knife which delivers the pipe cut the correct length. The large drain tile are made by removing the cavity for the flange, and using a plain stopper on the ram. Tile up to 8 feet in diameter have been made on such presses. Figure 132 shows some of the interior details. Figure 133 shows a very common hand press used principally in making roofing tile and a high grade of fire brick. A system of levers gives the desired pressure without the use of cams so often used in the large presses.

The represses for stiff mud brick are used to give a

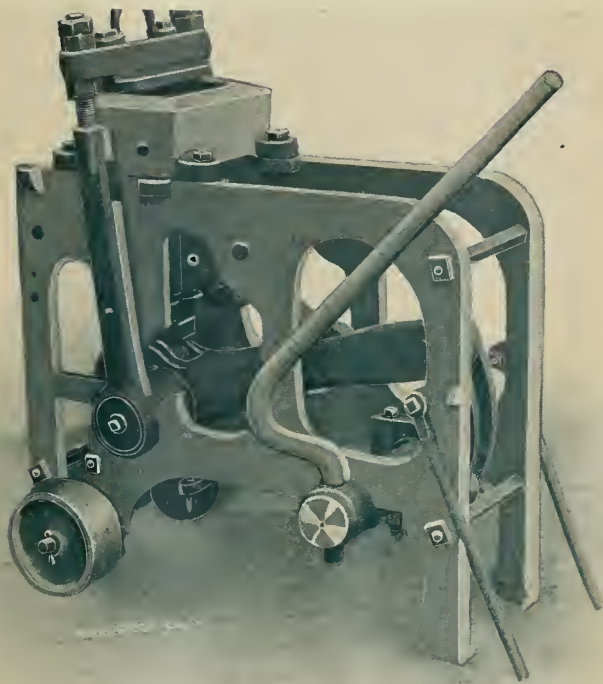
52-inch
Sewer Pipe Press,
Style "P"



Fig. 131.



Sewer Pipe Press Steam Cylinder.
Fig. 132.

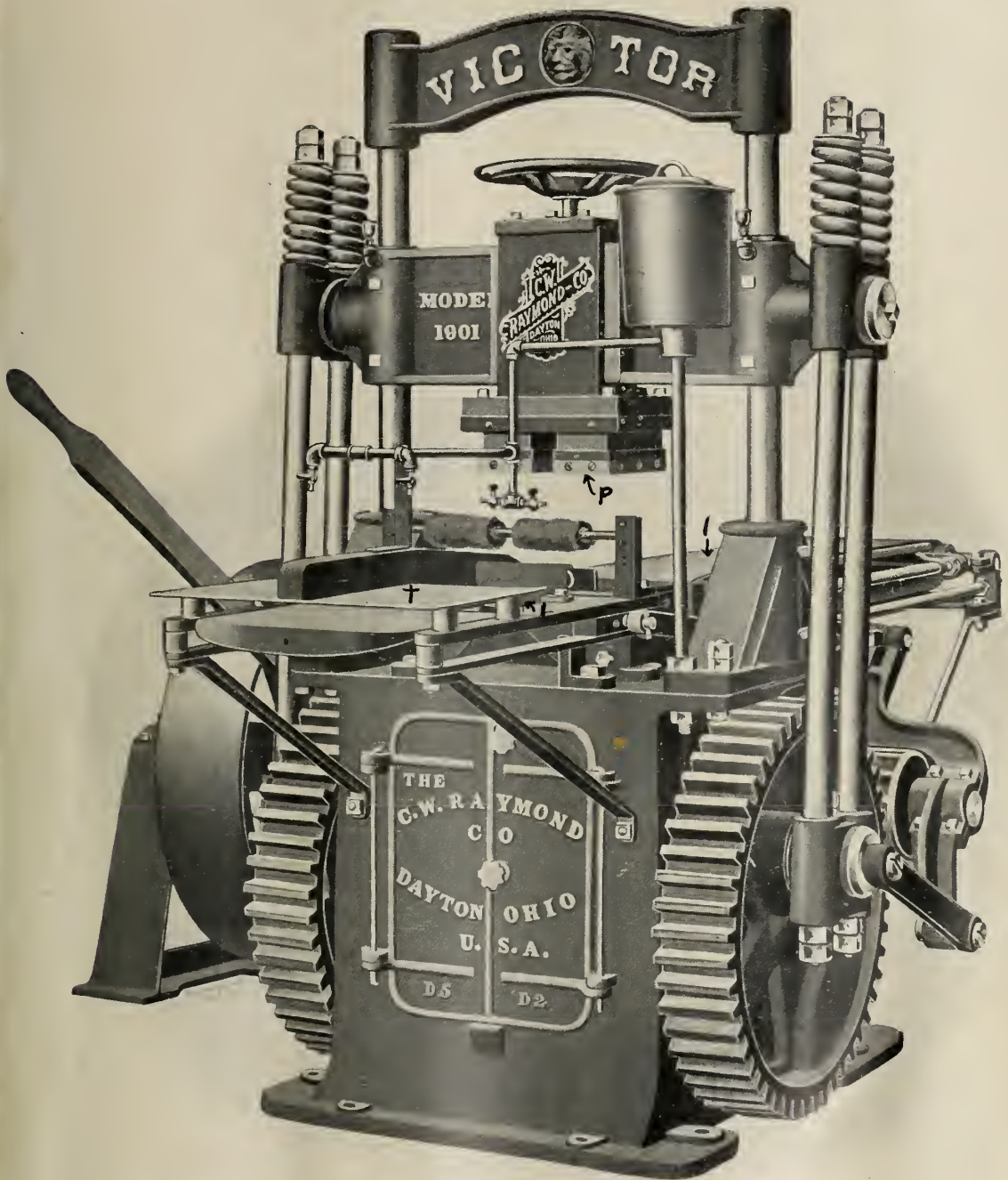


Hand Brick Press
Fig. 133.

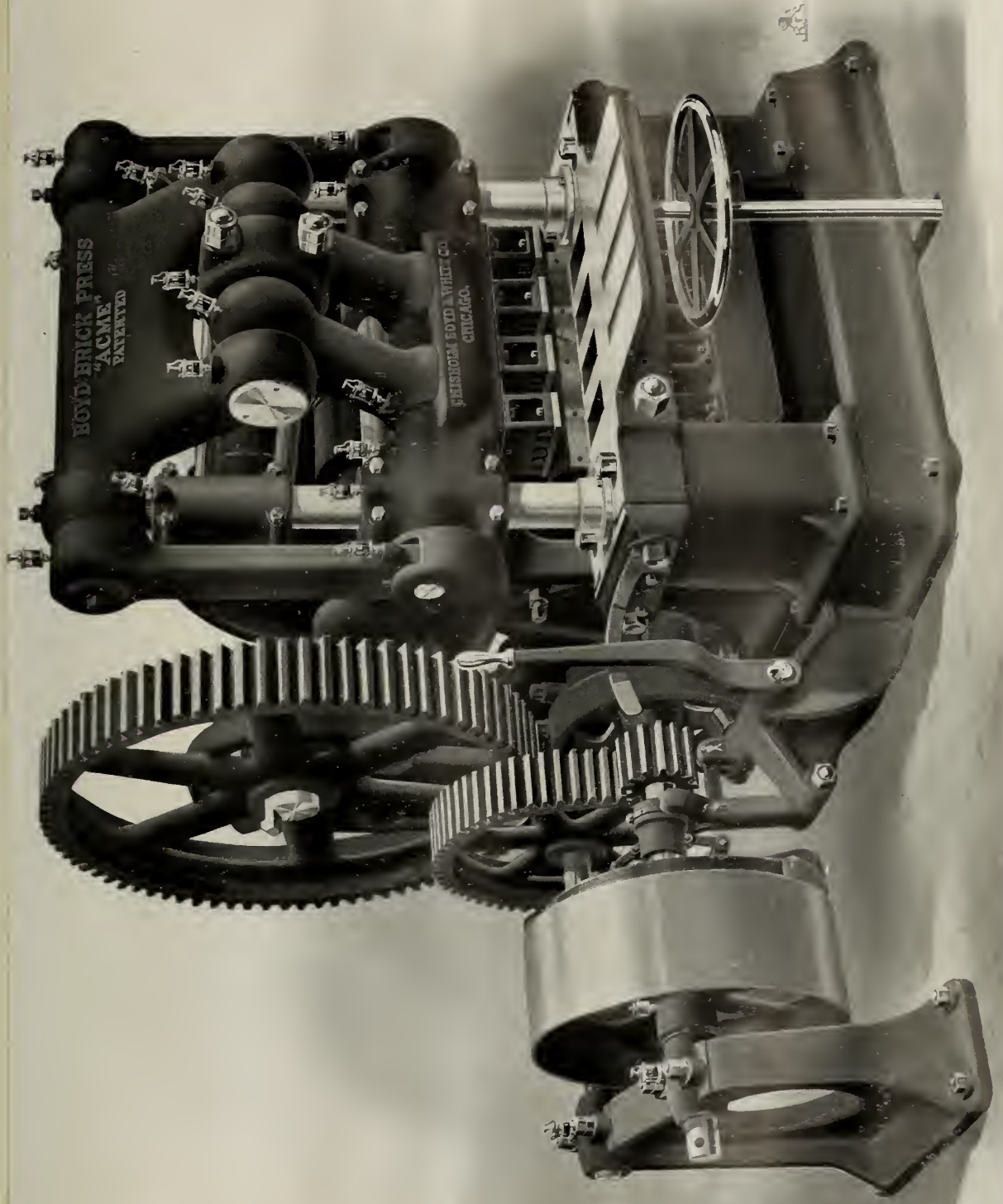
dense structure and a finished surface with square or rounded corners to the product. This increase of density is especially desirable in paving brick, because they are rendered more impervious to moisture. There are many different makes of this type of press, but all have the same principle involved, i. e., a straight line motion on guide rods of the press plates moved by excentrically set rods on gears. Figure 134 shows a machine representative of this type of machine. The brick are placed on the table t, and are slid down into the cavity l which has a catch sliding back and fourth. As the catch slides back, and the brick are slid down into l the press cover plates are press plates as they may better be called are moved upward, and the brick already pressed are lifted out of the press die. As the downward stroke of the die begins the catch slides the already pressed onto the delivery belt for the die bottom has been caused to rise to the top of the die cavity. At the same time the brick are slid into the catches, the press brick are are delivered to the car men on a delivery belt. These presses are capable of pressing up to 40 brick a minute.

Where a greater pressure is wanted as in the case in the dry-press process toggle joints, cams, or long levers excentrically set on gears are resorted to. In figure 135 a dry-press machine is shown which makes use of the toggle joint. The filling box b is moved forward, and fills the die with the fine dry clay, which is pressed by the cover plates. As the cover plates rise the filling box comes forward, and, when the bottom of the dies have been caused to rise to the top of the

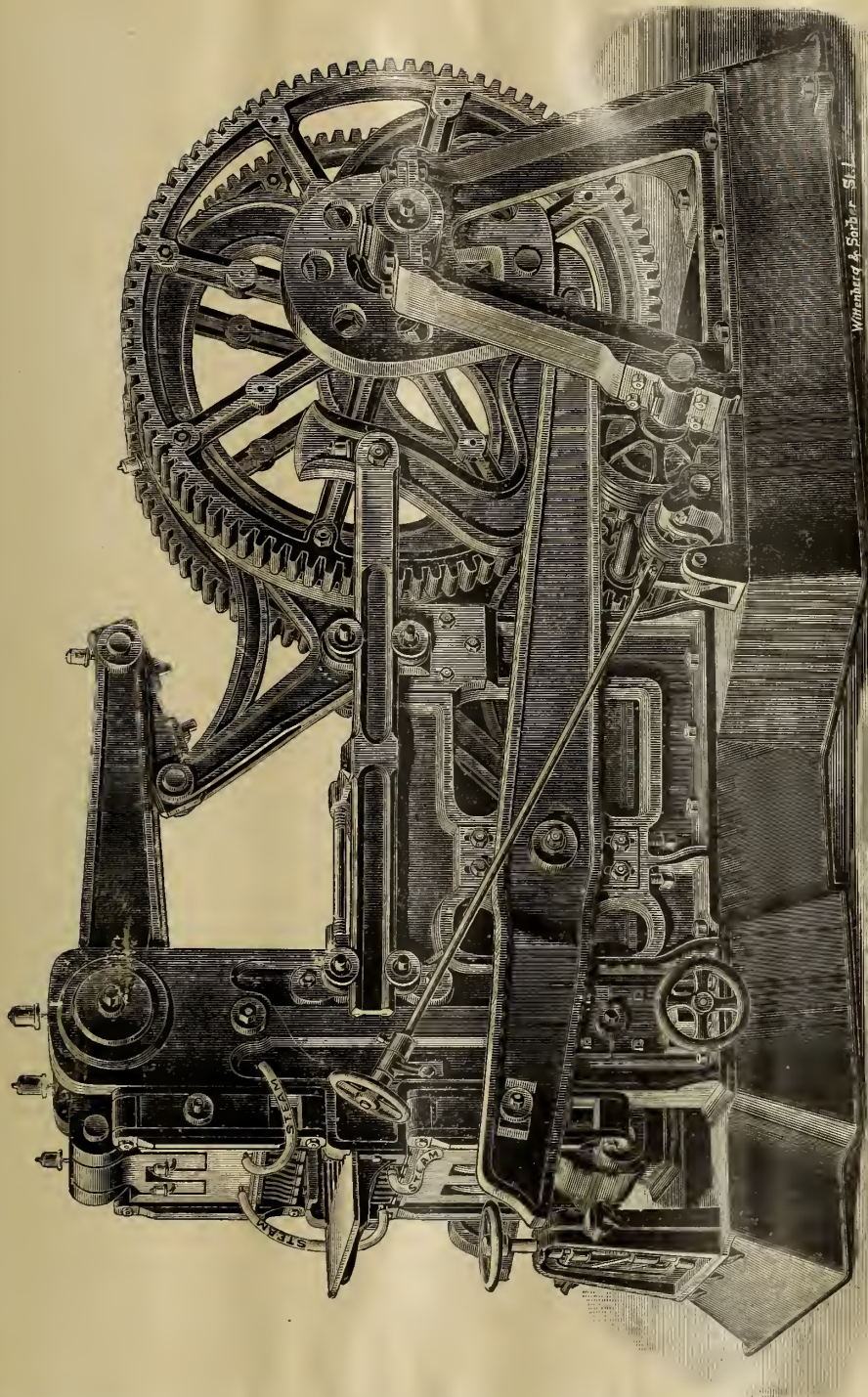
die boxes the pressed brick are pushed out upon the table in front. Figure 136 shows another table of different design with its manner of doing its work illustrated in figures 137, 138 and 139.



Stiff. Mud Repress.
Fig. 134.



Dry Press Fig. 135.

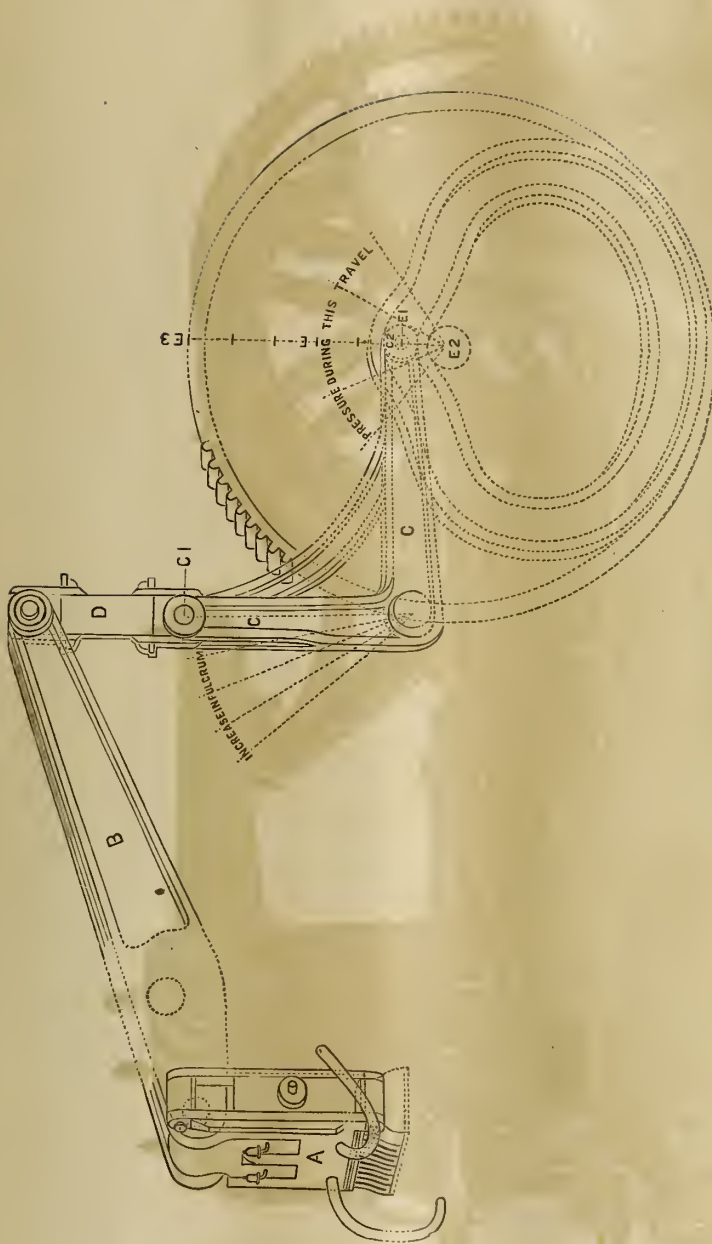


Dry Brick Press.
Fig. 136.



FORWARDING THE PRESSED BRICK ON TABLE AND FILLING THE MOLD.

Fig. 137.



PRESSING THE BRICK.

Fig. 138.



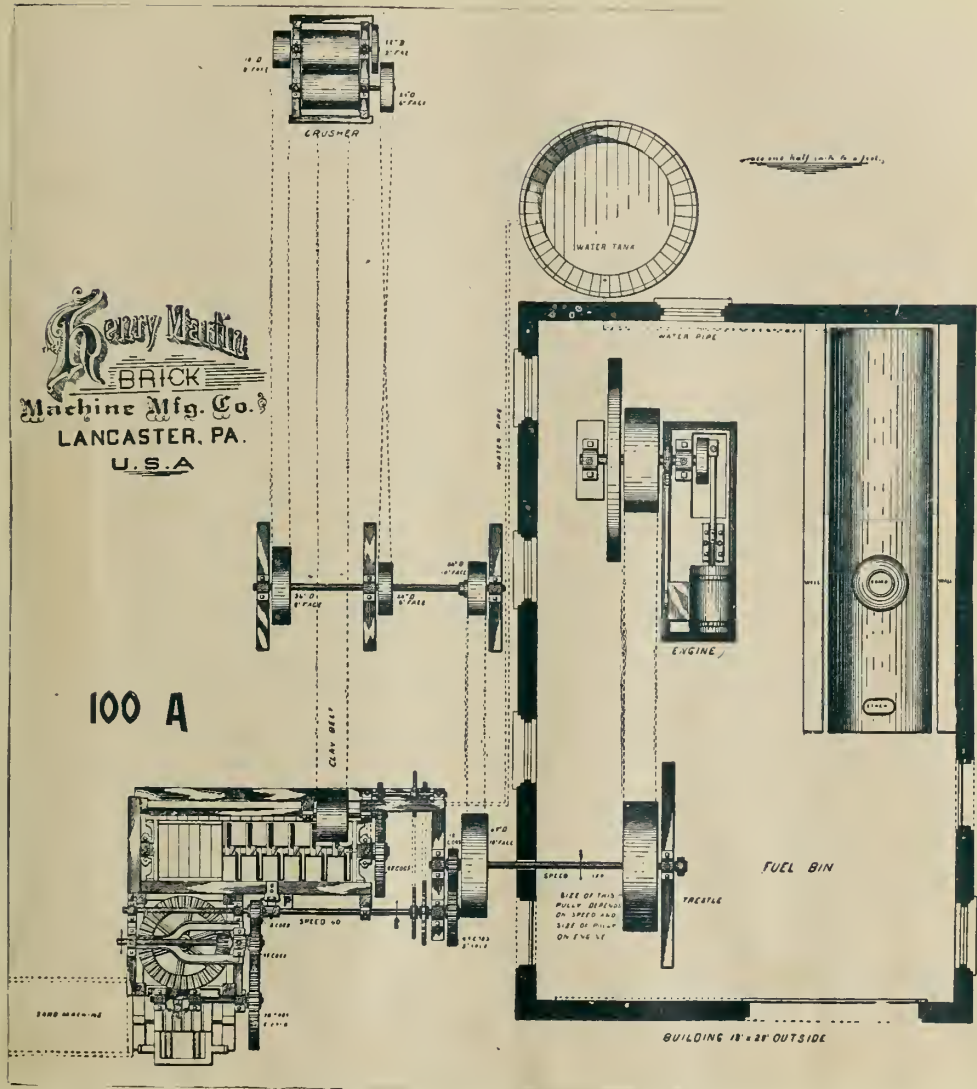
LIFTING THE PRESSED BRICK TO TOP OF MOLD.

Fig. 139.

IX. GENERAL PLANS OF PLANTS.

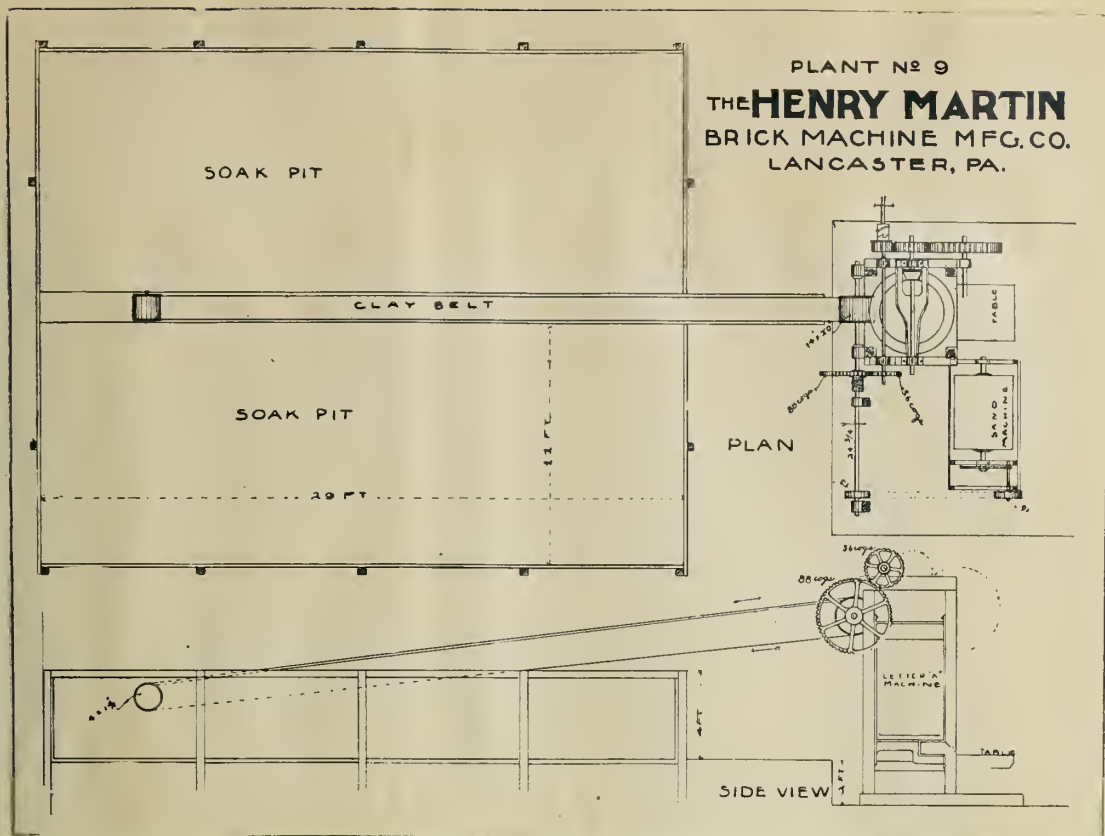
The laying out of a plant is a very serious proposition which differs with every erection. The position of the loading and cool tracks, the transfer system and its relative position to the kilns and heat ducts, are not likely to be the same in any two cases while the plan of the buildings probably the most important of all must be seriously considered. Economy of belting and shafting means economy of power and space, and economy of space generally means economy of labor. It is easily seen that when the erection of a modern plant is being considered the services of an engineer acquainted with the most modern method of dealing with the many problems which may come up, are almost absolutely necessary.

Figure 140 shows a common arrangement of a plant using the soft mud process of manufacture. Figure 141 shows the size of soak pits used in the same process with the relative position of the conveyor belt. Soak pits are generally used for the prepared clay ready to run into the pugmill of the soft mud machine. In some cases it is necessary to run the clay for a soft mud machine through a dry-pan and screen. In this case figure 142 shows an arrangement which with slight modifications may be used to advantage in almost every case of this kind. The same plan may be also adopted to some stiff mud plants. Figure 143 shows a most excellent arrangement for a stiff mud plant making paving brick. The path of the clay is traced as shown by a red arrow. In figure 144 may be seen a

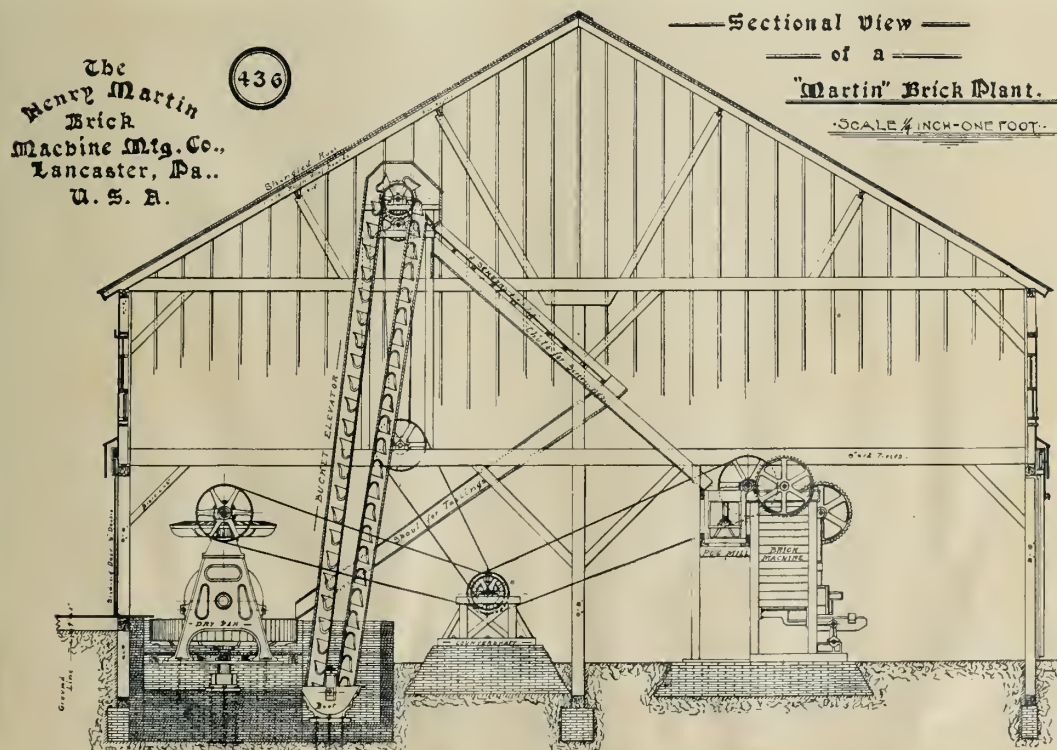


Plan of Soft Mud Brick Plant.
Fig. 140.

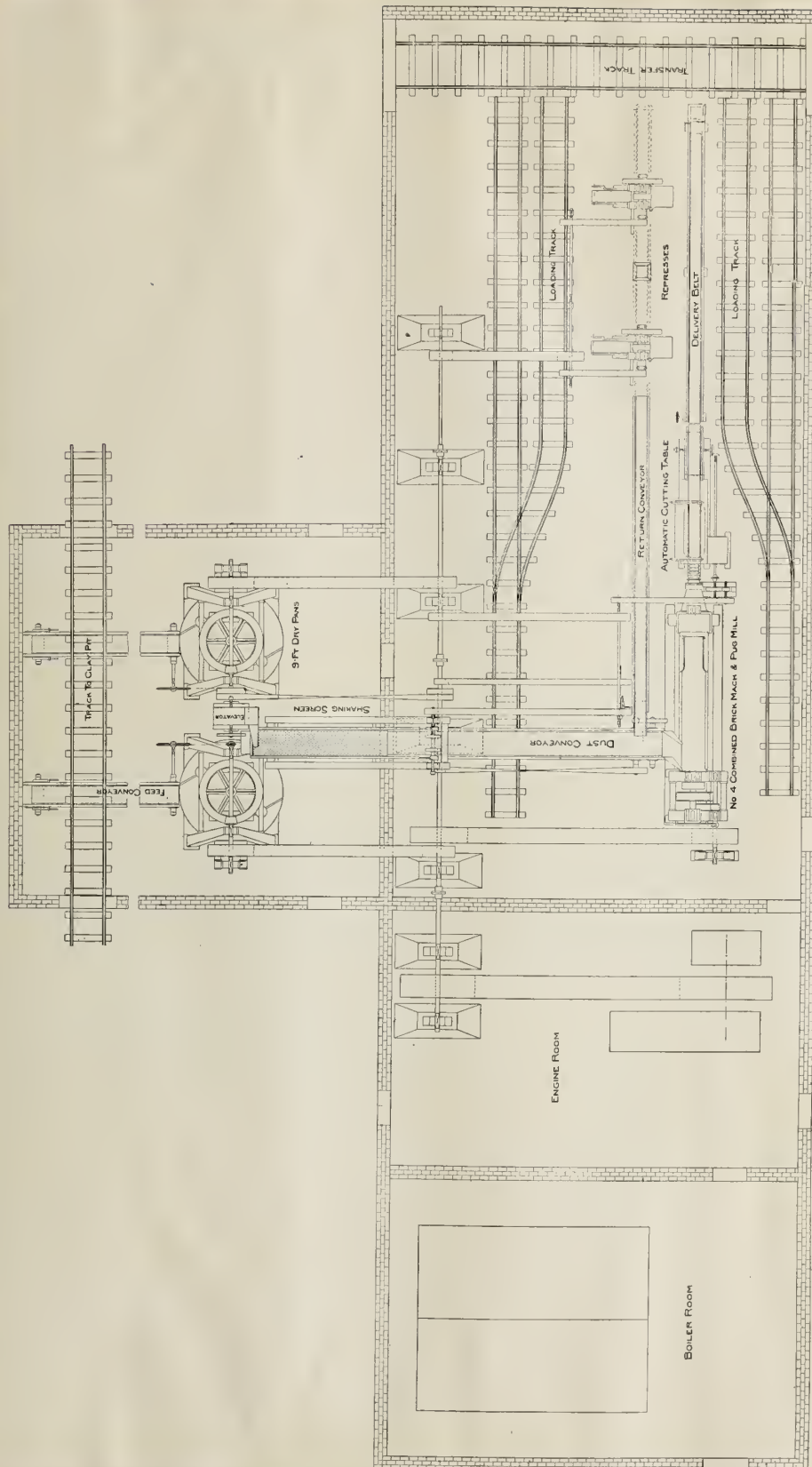




Plan of Soft Mud Brick Plant
 Fig. 141.



Plan of Soft Mud Brick Plant.
 Fig. 142.



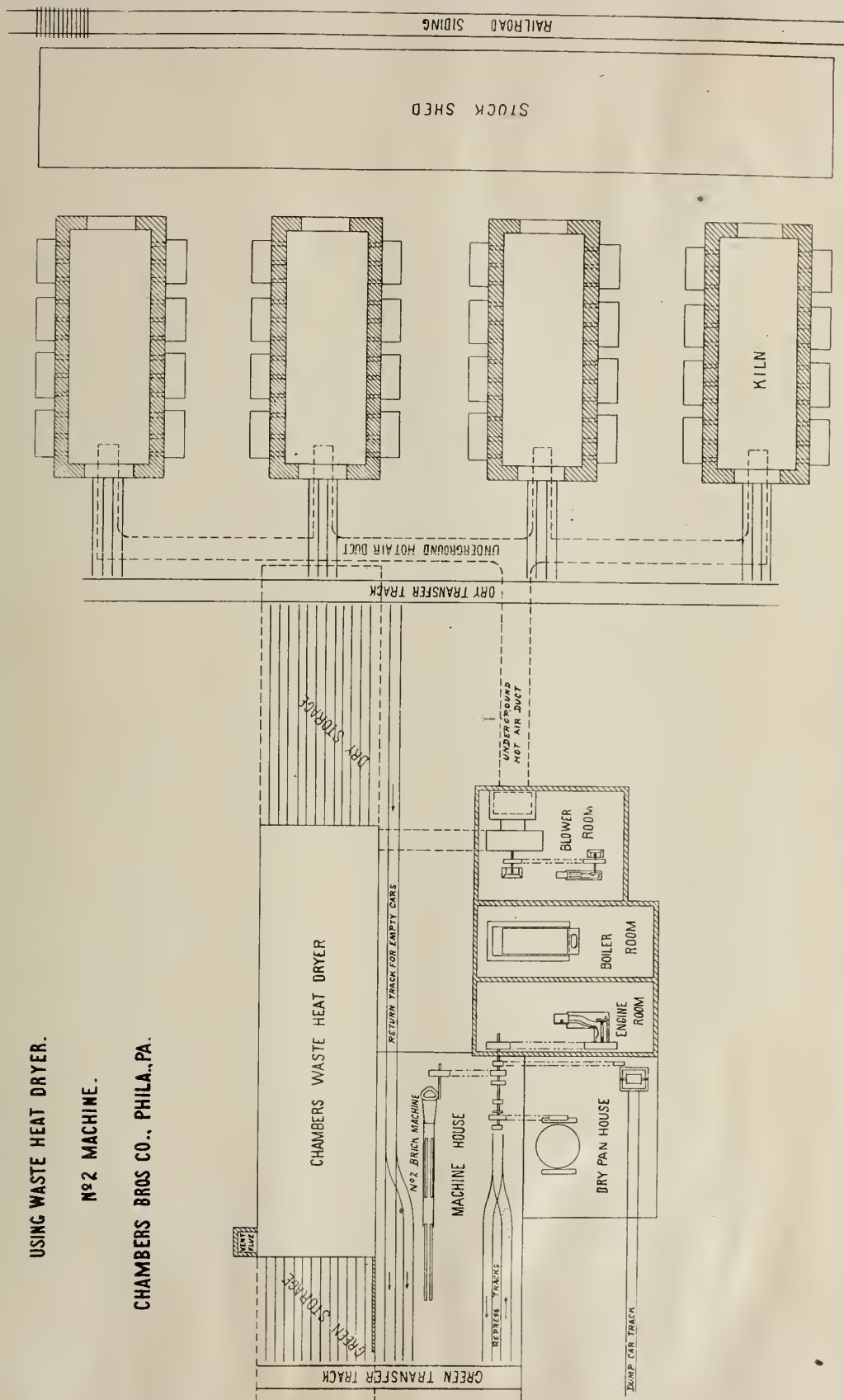
Plans of Paving Brick Plant
Fig. 143.

WORKS PLAN No 2

USING WASTE HEAT DRYER.

No 2 MACHINE.

CHAMBERS BROS CO., PHILA., PA.



Plan's of Paving Brick Plant
Fig. 144.



Stiff Mud Brick Machinery
Fig. 145.

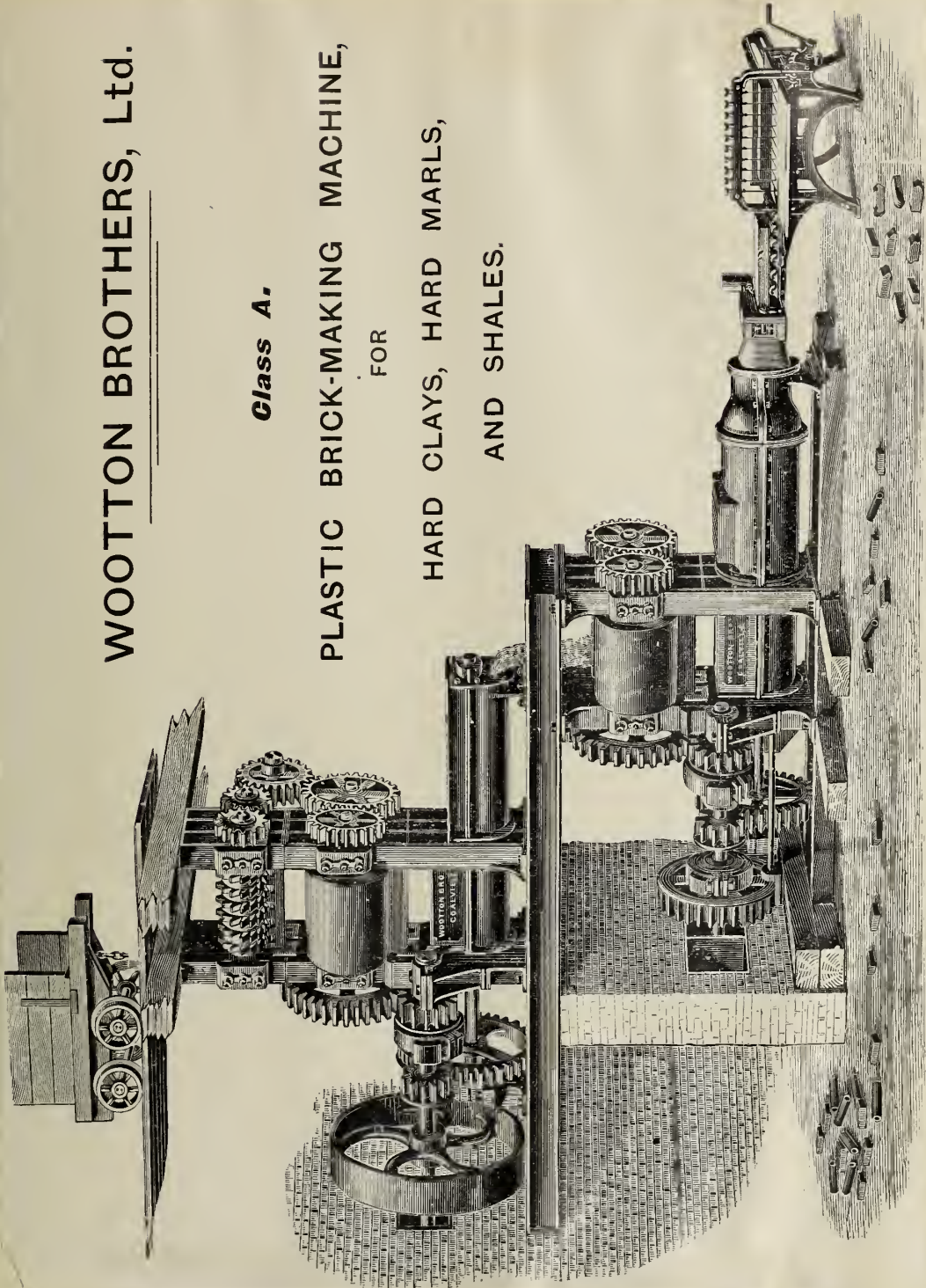
common installment where stiff mud end cut and repressed brick are manufactured. Such a plant is capable of turning out 60000 to 90000 brick per day. Figures 146, 147, and 148 show plans of brick plants in England. It will be noticed that the clay is always in the plastic state in these plants. The wet pan is much more used in the manufacture of common brick abroad than in this country where the main object is quantity and not good quality as it is in England. The custom of placing machines so that no conveyors or elevators are needed is a good one but necessitates very heavy foundations.

Figure 149 shows a very common arrangement for a dry-press plant. As is shown the clay is aged in a large storage house. No dryer is necessary since all the water is taken out during the watersmoking period in the kiln. Figure 150 shows an excellent arrangement of kilns and waste heat dryer with respect to the power and machinery rooms. Figure 151 shows the arrangement of kilns and plant in the Scott system of manufacture as further described in transportation and kiln.

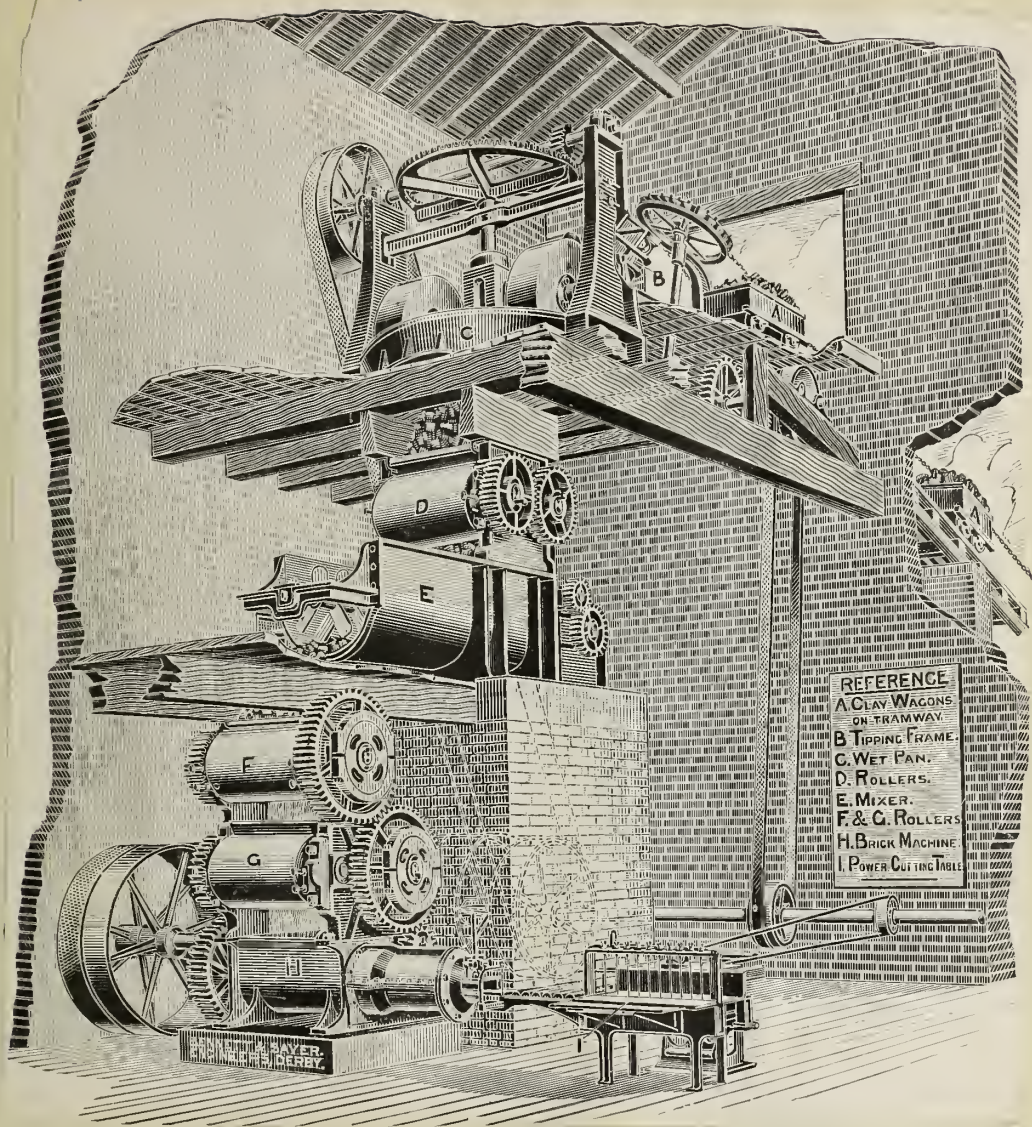
WOOTTON BROTHERS, Ltd.

Class A.

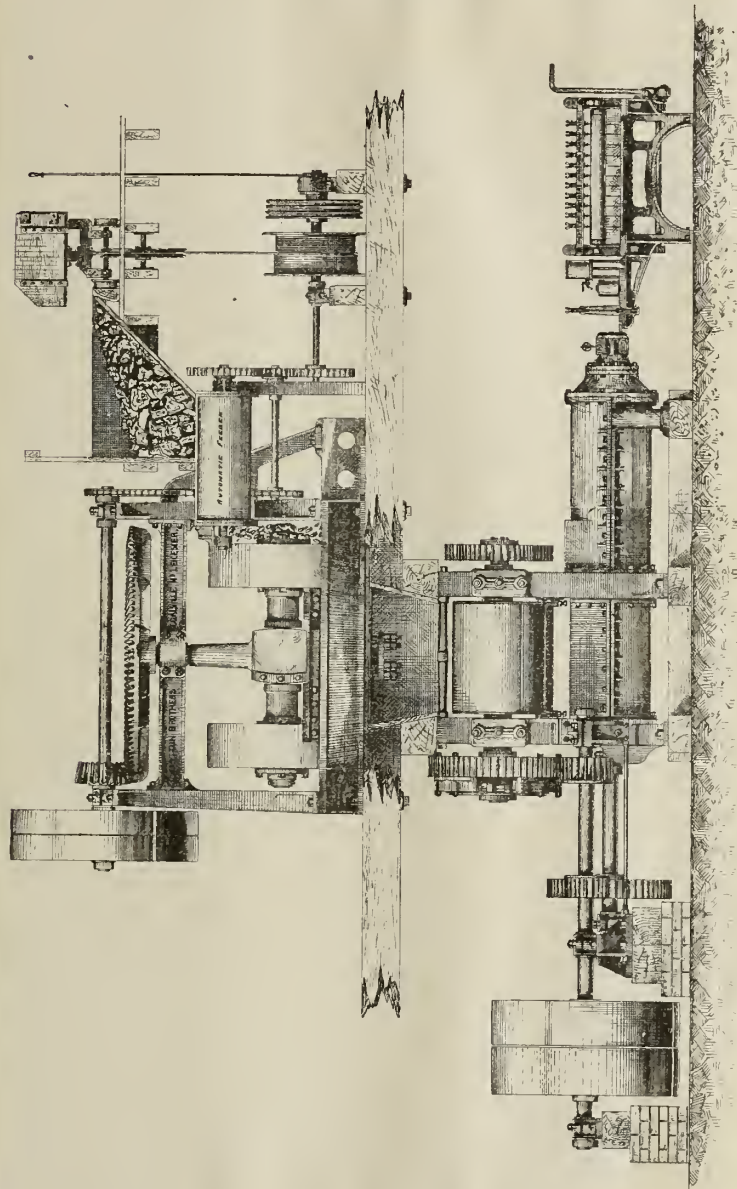
PLASTIC BRICK-MAKING MACHINE,
FOR
HARD CLAYS, HARD MARLS,
AND SHALES.



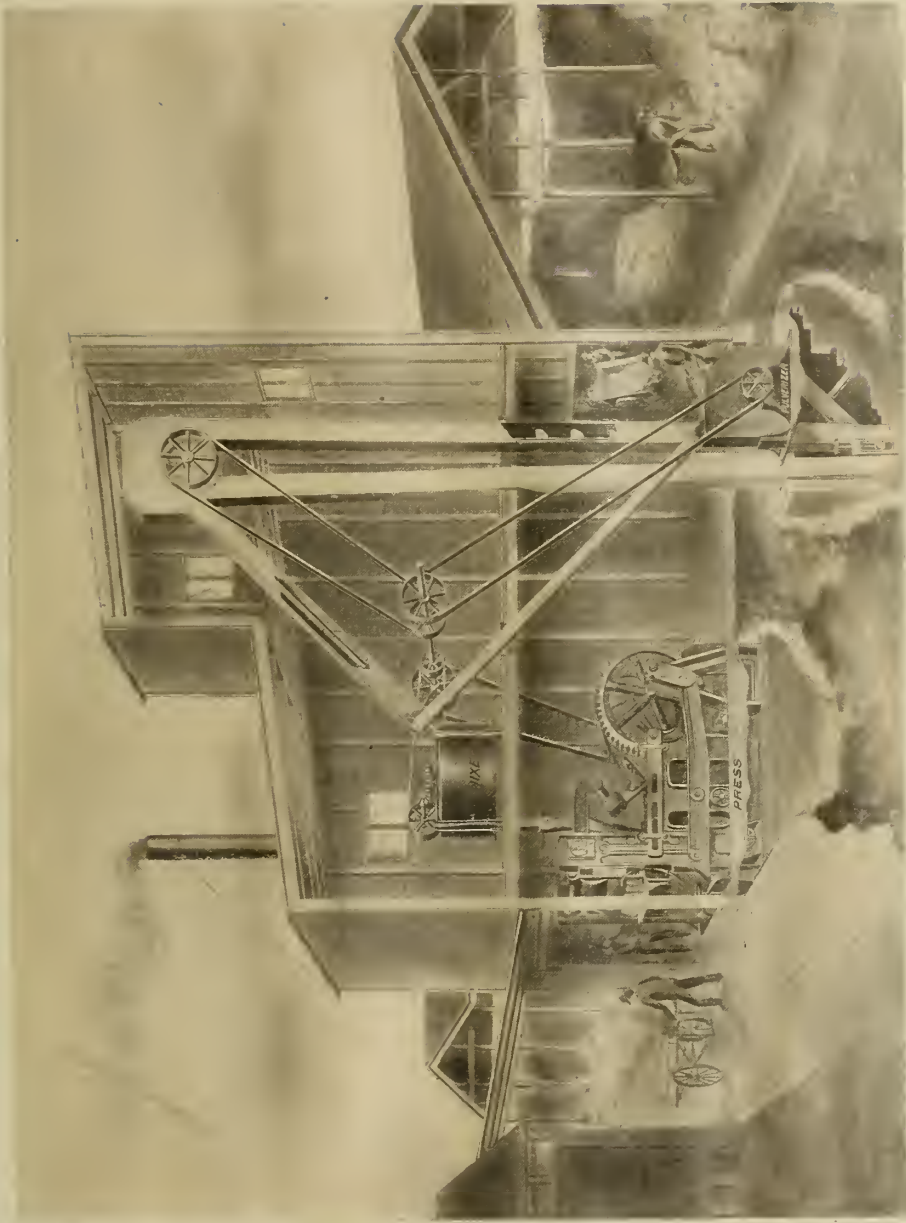
English Stiff Mud Brick Plant.
Fig. 146.



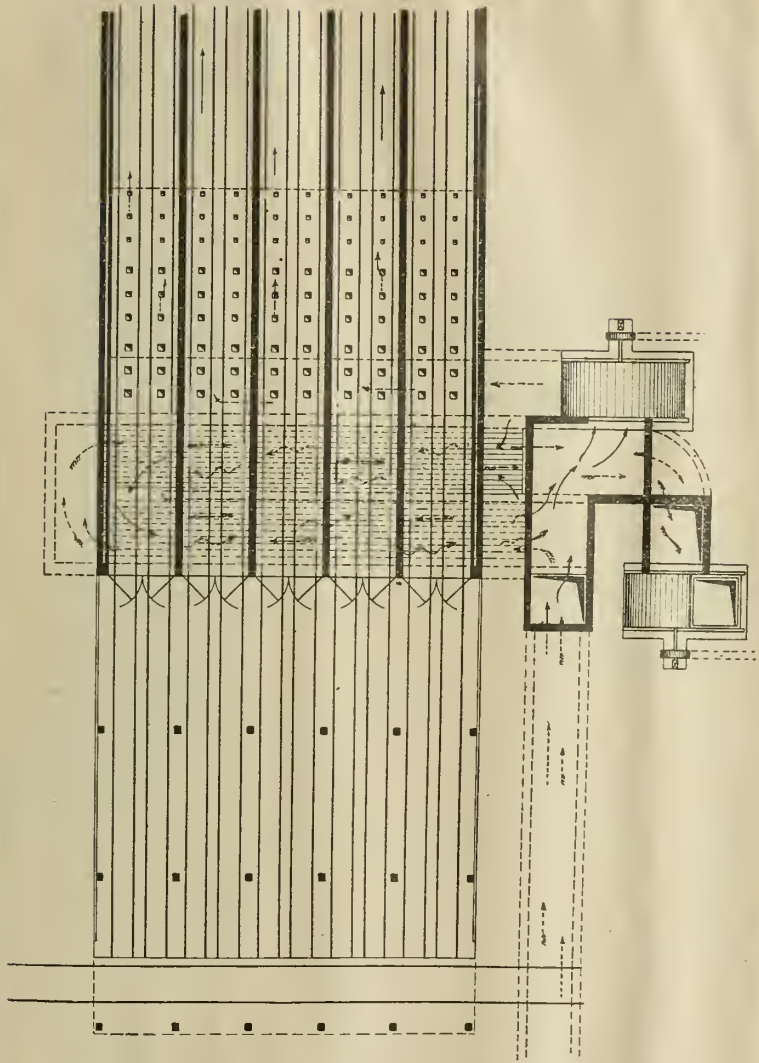
English Stiff Mud Brick Machinery.
Fig. 147.



English Stiff Mud Brick Machinery.
Fig. 148.



Dry Press Plant
Fig. 149.



Fin. 7

Plans of Waste Heat Dryer

Fig. 150.

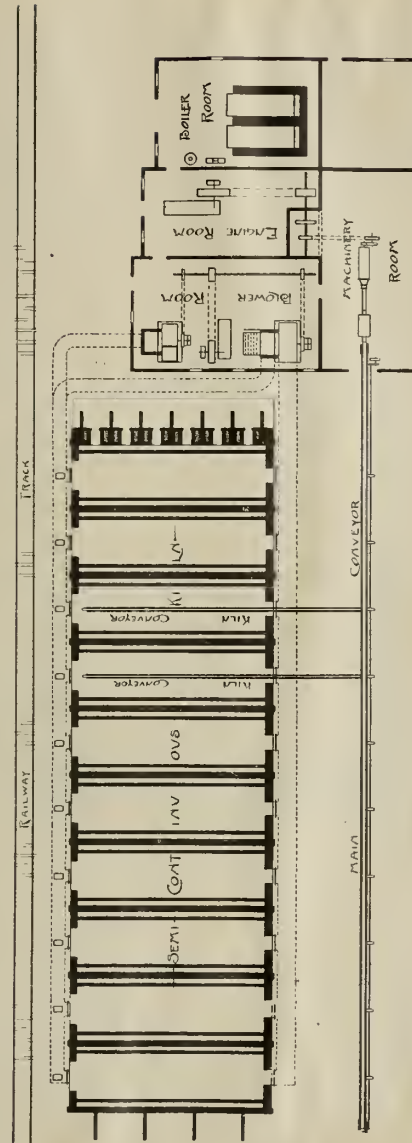


FIG. X

Plan of Plant Using Scott's Method Fig.151.

X. FACTORY VISITS.

1. Wabash Clay Co. Veedersburg, Indiana.

Figure 152.

This plant manufacturers a dark brown vitrified paving brick and blocks, and a high grade of stone ware of all shapes and sizes. The shale for this factory, obtained from a pit one-and one-half miles from the factory, is loaded into V shaped bottom cars of 44 yards capacity (water level) by a 70 ton Bucyrus steam shovel. The bank of blue shale, which is of a very dense structure, lies very compactly in the bank, and could only be excavated with a large and heavy shovel as used. The face of the pit shows about 25 feet of blue shale with 1 foot of coal directly beneath and 10 feet of yellow sand above. Four cars are pushed to the plant by a 15 ton dinkey locomotive of the Davenport Locomotive Works. The shale is dumped in a large storage house capable of holding about 3 weeks supply which is used in case of bad weather. The shale is wheeled by workmen with barrows to the dry-pans which are 3 in number of 9 feet diameter each. Two of these are of the Buckeye manufacture and the other is a Raymond. From the dry-pans, the ground shale is carried up a 58 foot chain cut elevator, which is inclosed in a steel housing 3 feet by 5 feet with provision in the boot at the lower end for taking up wear and adjusting the chains. The elevated shale goes down a perforated metal screen with perforations $1/8$ inch by $1/2$ inch, after which it passes over a Bonnot 5 foot piano wire screen with $3/32$ inch distances between the wires. The slope

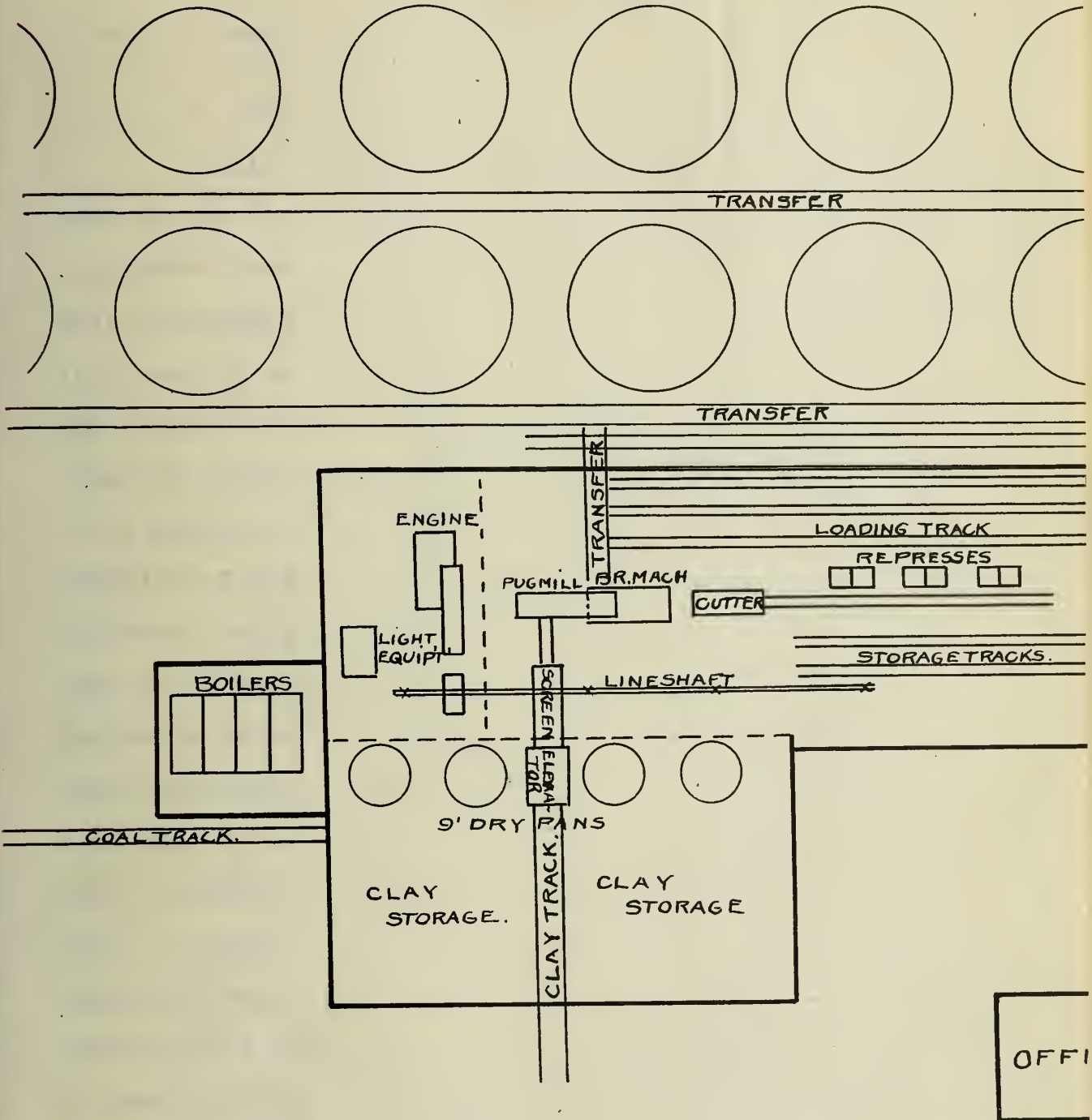
of this screen is about 50° from the horizontal. The clay then passes into a 12 foot Raymond pugmill and on into a Raymond (80,000 capacity) brick machine. After passing out the die, it is cut by a Bonnot automatic cutter of 16 brick capacity to the cut. The brick are then run out to 3 Raymond double represses, the brick are placed on steel deck cars of 450 brick capacity, and are dried in a waste heat dryer of 18 track of 15 cars capacity to the track. This dryer is fitted with a Buffalo Forge Co's. fan system with underground flues and goose neck connections with the kilns. The brick are burned in 21 round down draft kilns of 28 feet to 30 feet in inside diameter. The flue system is of the multiple type described and illustrated in the chapter on kilns. The openings in the floor are 5 inches by 8 inches about $2\frac{1}{2}$ inches apart each way on the floor. The fire boxes are of the ordinary slanting steel bar grate and solid bottom construction with $5\frac{1}{2}$ foot bag walls. The total number of fire boxes to the kiln is 10 in the 30 feet and 8 in 28 feet. The crowns are of single brick construction, and have a 6 foot rise. The filling of the kilns is accomplished from the cars which are transferred from the dryer tracks to a track running into the kiln. The emptying is by means of wheel barrows, which are run into box cars on a submerged tracks so the car floor is on a level with the yard. The storage yard lies upon both sides of the loading track as shown in the figure. The power for this plant is furnished by a 250 H.P. Bates Corliss engine running at 80 R. P. M. and using

YARD STORAGE BRICK

RAILWAY LOADING TRACK VANDALLIA

POTTERY STORAGE.

21 - 28' to 30' KILNS.



WABASH CLAY CO'S PL
VEEDERSBURG, INC
FIG. 152.

YARD STORAGE BRICK

RAILWAY LOADING TRACK VANDALLIA LINE

POTTERY STORAGE.

21 - 28'to30' KILNS.

TRANSFER

TRANSFER

TRANSFER

ENGINE

LIGHT
EQUIP

BOILERS

PUGMILL

BR. MACH

CUTTER

LOADING TRACK

REPRESSES

STORAGE TRACKS.

COOLING
TRACKS

DRYER

STORAGE
TRACKS

LINESHAFT

9' DRY PANS

CLAY
STORAGE.

CLAY
STORAGE

OFFICE.

WABASH CLAY CO'S PLANT
VEEDERSBURG, IND.
FIG. 152.

steam at 125 pounds pressure from 3-100 H.P. fire tube boilers. The light is furnished by a small dynamo run by a Westinghouse high speed engine. The power for the pottery is furnished by a 60 H. P. Westinghouse engine.

2. Veedersburg Clay Co. Veedersburg, Indiana.

This plant uses a shale similar in nature to that used by the first described plant. The shale at this plant is blasted, and loaded by hand into tram cars. The shed, into which the shale is dumped holds about 4 days run. The shale is ground by a 9 foot Bonnot dry-pan, and elevated by a belt cup elevator to a 5 foot Bonnot piano wire screen. The clay from the screen descends into a Bonnot combined pug-mill and brick machine of the Admiral Dewey type. This machine has a capacity of 110,000 brick per day of 10 hours but due to lack of power, and small grinding capacity the best that could be done was a run of 35000 per day. The brick were cut by a Bonnot automatic cutter, and after being run out on a delivery belt, were repressed on some occasions by 2 double represses of the same make as the cutter. The brick were placed on steel deck cars of 480 brick capacity, and fired in a waste heat dryer with 14 tracks each of 15 cars capacity. The tracks were each separated from the others by partition walls making what is known as the tunnel type of dryer. The burning for the plant is done in 12-30' down draft kilns of similar construction to those of the previous plant just described. The kilns of this plant were in a bad condition, as was also the machinery at

the time of the writer's visit. The plant did not have enough power to operate economically because the machines could not be run at their capacity. The plant is a good example of construction by a stock company ignorant of all clay working engineering. It was in the hands of the receiver at the time of the writer's visit.

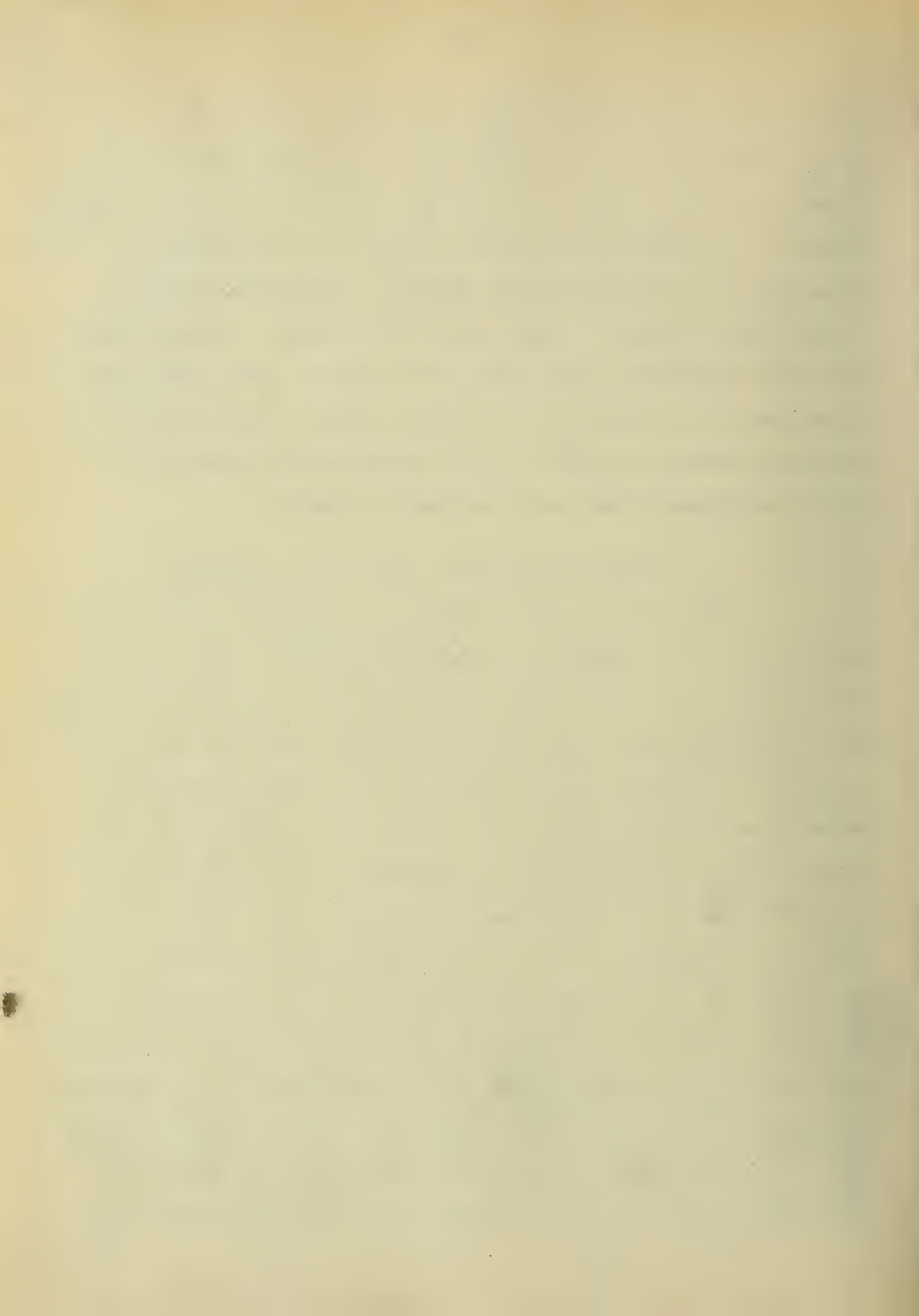
3. Postum Brick Co. Crawfordsville, Indiana.

The shale for this company was excavated about four miles from town by blasting. After loading into coal cars by hand, it was hauled to the plant on the Vandallia rialroad. The side track was covered by a part of the dry-pan house so that the shale could be thrown directly into the crusher which was of the jaw type made by the Schallerback Son's Co., of Kansas City, Mo. The pieces as they come in the cars are so large that a dry-pan can not reduce them without excessive strains in the machine. The jaw crusher did this easily and required little power. The clay from the crusher was then run into a single 9 foot Raymond dry-pan in a granular condition, and further reduced. After passing through the dry-pan it is carried to the piano wire screen by a vertical belt cup elevator. The pugging is done in a 12 foot Raymond mill. The clay then passes through a "777" type Raymond brick machine. The cutting is done by a 12 capacity Raymond hand cutting table after which the pressing is accomplished in 2 double Eagle represses made by the American Clayworking Machinery Co. The

brick are dried on steel decks dryer cars of 340 brick capacity in a 8 track dryer. The kilns used are of two sizes. 8 of these kilns are 30 feet in diameter, and 4 are 26 feet in diameter. The general construction of the kilns did not differ from those of the Veedersburg plants. These kilns required 8 days with 20 tons of coal to burn the pavers. Large stacks were used here with four kilns to the stack. The power was furnished by a 16x30 250 H. P. Bates Corliss engine which was supplied steam by a 250 H. P. fire tube boiler stoked by a Jones underfeed stoker using washed pea coal.

4. Western Brick Co. Danville, Illinois.

This plant is the next to the largest in the world having an annual capacity of 60,000,000 brick. This company manufactures at present only stiff mud side cut building brick, and a soft mud sand face brick. A paving brick was made up to the fall of 1906 but the clay used for these blocks was mined from 250 feet below the surface at a rather great expense, and because of this the manufacture of paving brick was discontinued. The company owns about 400 acres of land with shale varying from 30 feet to 55 feet in depth overlaid with 3 to 10 feet of a glacial clay mixed with a high percentage of gravel. Directly beneath the shale is a lead of a very good grade of bituminous coal which varies from 4 to 6 feet in thickness. The coal is excavated just after the clay is taken out. The Vermillion river runs through the clay fields, and furnishes water to a plant pumping for a hydraulic stripper



which washes the surface material to the banks of the river where it is caught in a wicket of tr^es and straw to prevent its flow into the river. This method of stripping is very cheaply carried on in this case because of the abundance of coal and water. The clay is taken from the bank by a 60 ton Bucyrus steam shovel, and loaded into side dump cars of 2 yard capacity, which are hauled in trains of 4 by a small dinkey locomotive about 1/4 mile to the foot of an incline about 400 foot in length. The cars are hauled one at a time up this incline by cable, and are dumped above the floor where the grinding is done. Five Raymond 9 foot dry-pans especially built for this company are used to crush the clay. After crushing, and grinding in the pans the clay is elevated by rubber conveyor belts to the pugmills. These belts are set at an angle of about 25° from the horizontal. One conveyor has cups while the other which is at a little less incline has none. The pugmills used are of the American Co's manufacture and are 14 feet in length. The stiff mud machines are of Raymond manufacture. The cutter used is a Chambers manufacture. Four double represses of the Eagle type are used in the manufacture of the pressed building brick. The soft mud machine is of the Monarch manufacture. The brick are loaded upon steel deck dryer cars, and run into a 55 track waste heat dryer of the tunnel type. The ware is burned in 58-25feet and 30 feet round down draft kilns of the same construction of all those previously described. Power is furnished by a 350 H. P. Bates Corliss

engine using steam from 4-100 H. P. fire tube boilers. Because of large capacity and splendid shipping facilities with cheap coal and labor, the plant does an enormous business.

Streator Paving Brick Co. Streator, Illinois.

The clay used by this company is a fine grained shale which covered by 20 feet of top clay must first be stripped off because of the limestone pebbles mixed with it. The shale which is about 22 feet in thickness is underlaid by a 4 foot lead of coal, which has partly been mined. The shale is excavated by a Thew 25 ton steam shovel which is too light for the work, and is to be replaced by a heavier shovel in a short time. The clay is hauled to the plant by a wire rope tramway system using 2 yard cars. The clay is crushed in a 9 foot dry-pan of American manufacture, and is screened in a perforated metal screen 12 feet in length and 2 feet wide. The perforations of this screen are 1/8 inch wide and 2 feet long. The clay for a 4 mould Franhenfield dry-press is taken from a bin into which the screens empty their product, while the pugmill also receives its supply from the same source. The pugmill is 12 feet in length and of American manufacture. The pugged clay is conveyed to the American combined brick and tile machine by a spiral conveyor of 8 inches in diameter. The green clay column from the machine is cut by an American rotary cutter, and pressed by the same companies Eagle double represses. The brick are loaded upon double wooden deck cars the decks of which are 18 inches apart. The dryer which has 9 tunnels is 60 feet long

uses live steam in 7-1 inch pipes laid between the rails and 11-1 inch pipes on each side. The burning is done in 3-24 foot kilns and 4-30 foot kilns of the same flue system as the plants described. Power is furnished by a 150 H. P. slide valve engine using steam from 2-80 H. P. fire tube boilers.

Barr Clay Co., Streator, Illinois.

The clay for this plant is excavated by a 65 ton Bucyrus steam shovel from a 25 foot bank of hard sandy shale of a blue color. There is about 6 feet of yellow top clay overlaying the shale, and two feet of coal beneath the same. The clay is hauled about $\frac{3}{8}$ of a mile by means of tramway and cable. The cars are pulled to the top of a hill, upon which the winding drum and engines are allowed to run about 700 feet beyond on a down grade to the dry-pan shed into which the cars are again pulled back to the top of the hill by the cable, which, by an arrangement of sheave wheels, has allowed the cable to double under the cars as they start down hill. As the cars pass the hill back they gather enough momentum in their decent down grade to carry them to the pit and shovel. The clay is ground in 2 English manufactured dry-pans of 9 feet diameter and in one of the same size made by the American Manufacturing Co. The clay is elevated by a 12 inch belt cup elevator with cups 3 feet apart. It is screened by a 12 foot Dunlap perforated screen and a 5 foot Bonnot piano wire screen. The mixing is done in a 12 foot pugmill, and the moulding by a 90000 capacity machine both of American Co's. Manufacture. The clay is

cut, and pressed by a rotary cutter and 6 Eagle represses of the same company's manufacture. The spoiled brick are conveyed back to the machine by an overhead conveyor running from the lower end of the delivery belt. The dryers used are of two kinds. 1. The largest dryer has 14 tunnels of 15 cars to the tunnel, and uses waste heat from a double steel flue taking heat from the tops of the kilns by a suction fan draft from a 90 foot Buffalo fan. 2. The other dryer has but 10 tracks of the same capacity. This dryer uses the exhaust steam from the engines in heating. The kilns are 25 in number. Eight of these kilns 15 feet by 80 feet in length using down draft, and have a capacity of 180,000 paving brick. The fire koxes number 9 on each side, and are of the common horizontal bar type with swinging iron doors. The grates are about 5 feet in length, and are of cast iron. The flue system consists of a large central flue with small laterals. Part of the floor is solid, and the remainder is covered by the open floor brick. The stack is at one end, and between two doors used for filling and emptying. The 17 remaining kilns are of the round down draft type and have radial flues with an entirely open floor work. The furnaces are similar to those of the rectangular type. The stacks are arranged so that most of them are attached to four kilns. The power is furnished by a 250 H. P. Allis Chalmers Corliss engine, which recieves steam from 2-B. & W. boilers of 150 H. P. each which are hand fired. According to indicator cards in possession of the engineer, and counts taken

of brick being made at the time 71,500 foot pounds of work is required to manufacture one paving block the standard of which is 3 inches by 4 inches by 9 inches.

American Brick and Tile Co. Mason City, Iowa.

The shale of this territory is of a very old deposit being of the Davonian age. This strata is in most places a great distance beneath the surface, and only outcrops, or comes near the surface at a few places in the eastern states, and still fewer in the states west of the Mississippi River. In Canada the sedementary deposits were not formed to any extent, and therefore this shale is not found in that section. It is noted for its fine soapy nature with a characteristic absence of foreign clay substance. This shale found at Mason City is about 25 feet in depth, and quite thoroughly weathered. It is covered by 8 feet of fine sandy yellow shale known as Hackberry. At this plant a tramway about 400 feet in length with bottom dump cars is used to transport the material from the pit, where it is loaded by hand to the granulator, which is of Brewer manufacture. The shale is reduced in this machine to pea size. Smooth conical rolls and a 10 foot Brewer pugmill farther reduces the shale to a plastic condition. An upright Brewer combined brick and tile machine is used for moulding. The clay is cut by Bensing automatic cutting tables. The ware is then set upon wooden deck cars, and dried in 9 track dryer using the heat from the exhaust steam which is run through heating coils in connection with fan blowers. The fans blow

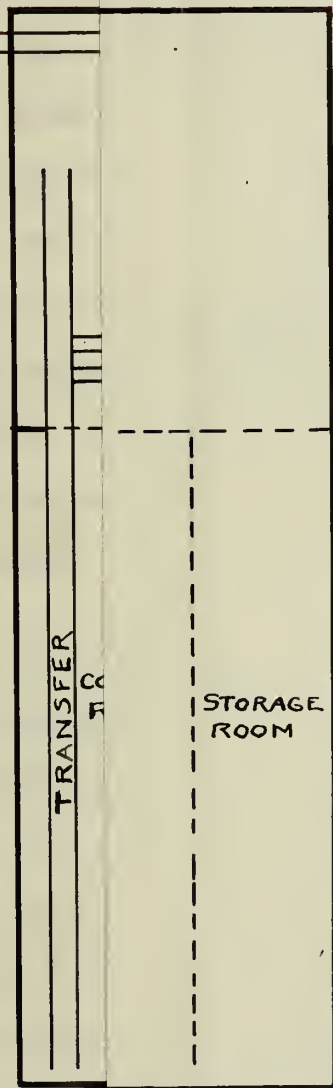
the air heated by passing over the coils into the dryer. This clay dries in 5 to 8 hours, and, therefore, only a small dryer is needed for a large output. The ware is burned in 11-30 foot down draft kilns with solid bottom T flue construction. The T-flues are covered with the ordinary floor brick. The grates are in part of the ordinary horizontal type with arrangements made in part for shaking. Part of the grates are of cast iron set at a slight slant from the horizontal. These grates seemed to have no advantage over the others. One of the parallel down draft kilns has the double concentric ring flue. A description of this flue will be found in the chapter on burning. The power is furnished by 1-150 H. P. four valve Erie City engine using steam from 3-60 H. P. Erie City fire tube boilers. A new plant is to be erected by this company with Brewer equipment, and a combined steam and waste heat tunnel dryer with two decks above the tunnels for the drying of large tile and sewer pipe. Arrangement has been made for the installation of 48-30 foot down draft kilns all within easy transfer and railroad loading distance.

Mason City Sewer Pipe Co., Mason City, Iowa.

Figure 153.

The clay and haulage is almost exactly the same at this plant as at the one just described. The difference in the clay is that at this plant the pit contains a few thin sandstone strata. The method of reducing is the same at this plant, as is all the others in this city, as at the one just described. The moulding in this plant is done in a Madden

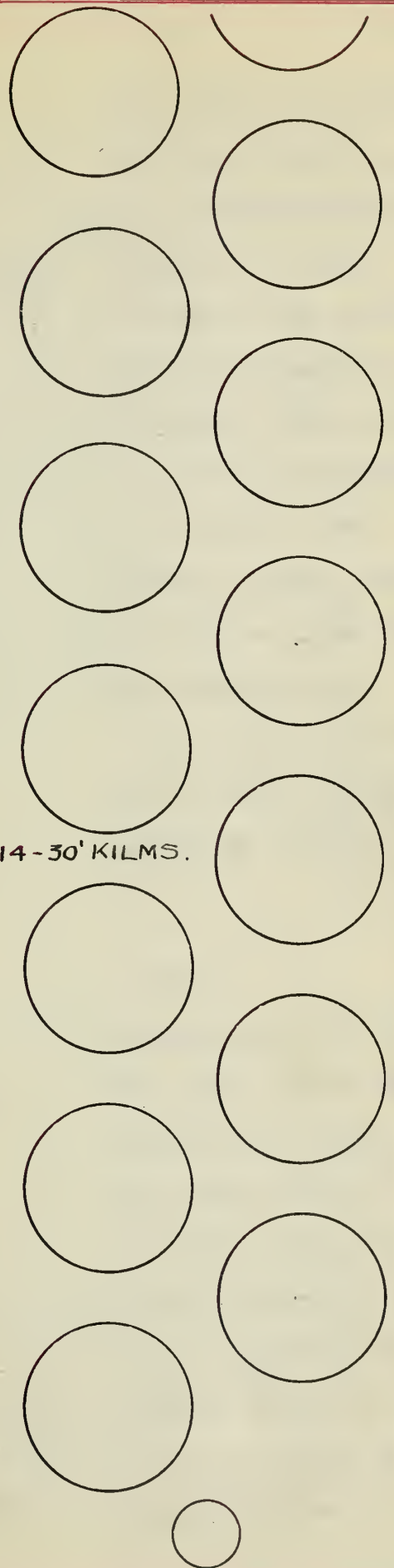
PLANT



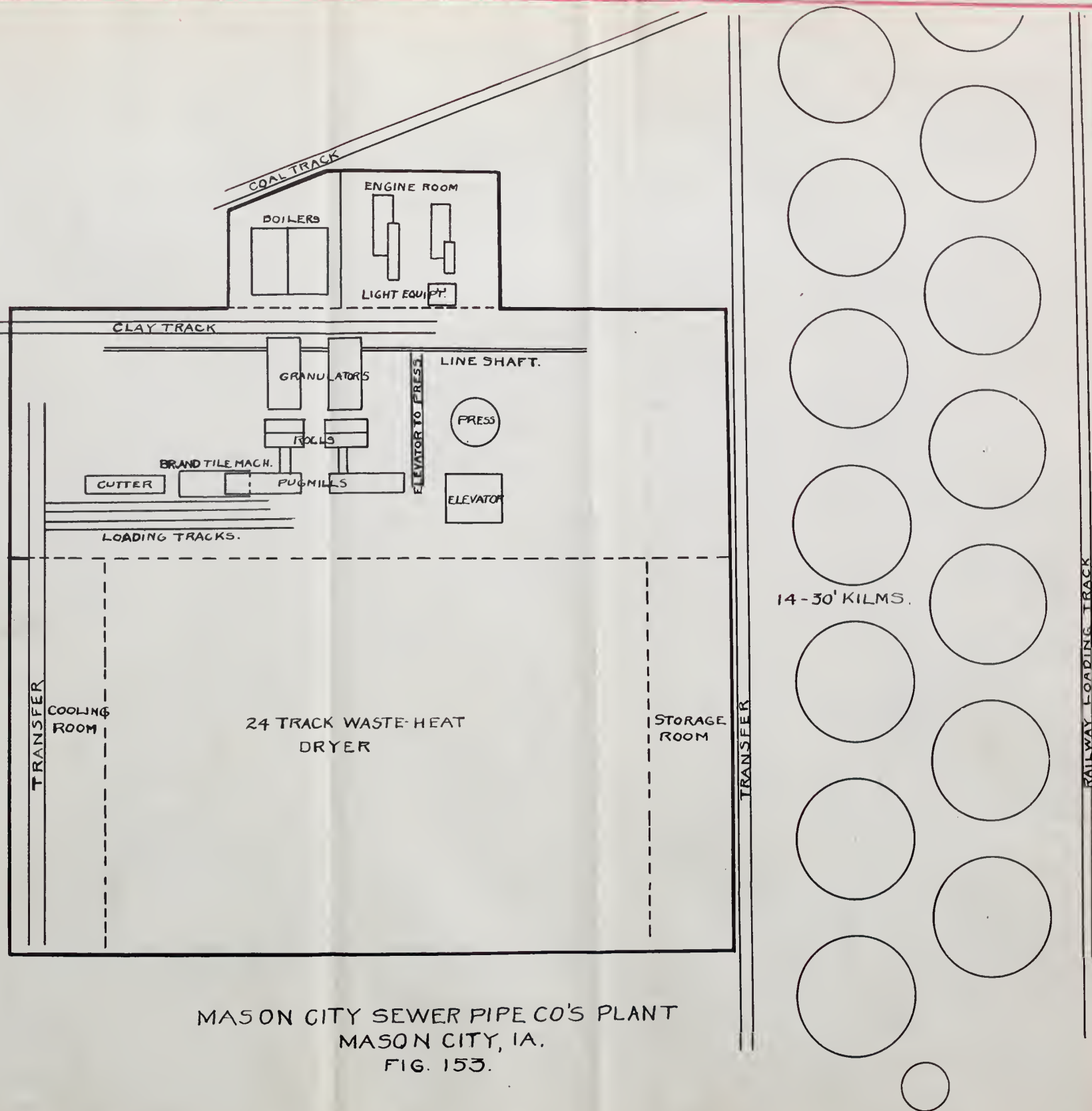
TRANSFER

STORAGE
ROOM

14-30' KILMS.



RAILWAY LOADING TRACK



machine constructed for either brick or tile. Bensing tables are used. A sewer pipe press is also used at this plant for sewer pipe and large tile. These are dried in a single deck dryer above the tunnel dryer which has 24 tracks of 15 cars capacity each. The burning is done in 14- 30 foot down draft kilns which are divided into two parallel rows set staggered with reference to the transfer and loading tracks. The draft for the whole number is divided between two 125 foot stacks of 6 feet inside diameter located at the ends of the two rows. The waste heat from the kilns used in the dryer is taken from the kilns by a system of underground ducts and goose necks leading out of the kiln doors with a suction fan interposed to furnish the necessary draft. The power for this plant is furnished by 1-175 H. P. Murry Corliss engine and 1-100 H. P. engine of the same manufacture. The steam is furnished by 2-150 H. P. fire tube boilers.

Mason City Clay Works, Mason City, Iowa.

The equipment of this plant is the same as used in the above described with the exception of the dryer and kilns. The waste heat dryer, which has 21 tracks with three tracks to the tunnel, and 15 cars to the track, has a fan suction from the kilns, and a fan suction out of the dryer. The kilns, which are 9 in number, are the same in size and construction as the two above plants. The kilns are set in a square with loading tracks on each side and a double transfer system as is necessitated by this arrangement. The power is furnished by Murry Corliss engines using steam from fire tube boilers. Ac-

cording to indicator cards in possession of the engineer, and counts of building brick taken at the time only 59000 foot pounds of work was required to make a brick. This low work required is probably due to the soapy nature of the clay.

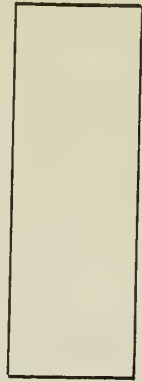
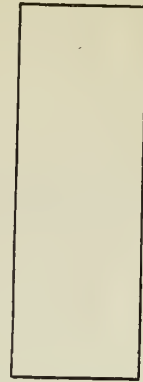
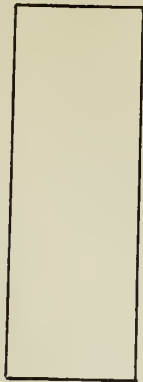
Mason City Brick and Tile Co. Mason City, Iowa.

The only difference in this plant from the one just described is in the dryers and kilns. There are used two dryers at this plant. The one has 9 tracks with three tracks to the tunnel, and receives its heat from 7-1 inch pipes using live steam directly under the cars. The second dryer uses waste heat. It has 15 tracks of 15 car capacity, and is arranged with three tracks to the tunnel. There are 9-18 foot round down draft kilns with the same furnaces and flues as those used at the other plants. They have 4 of the 28 foot kilns of the same type. This plant is the oldest in the city, and consequently is not well planed because of the manny additions from time to time.

Purington Brick Co. Galesburg, Illinois.

Figure 154.

At Galesburg is located four factories operated as one with the largest capacity of ay such plant in the world. The output during 1906 was 84,000,000 paving brick and blocks with seconds, sold as building brick. This is a record which cannot be comprehended by the average person. If all were loaded on a train with 30000 brick to the car the train would be over 25 miles in length. Here the company keeps 5 large



ROOM

EAT AND
HEAT DRYER



ENGI

ROOM

PUGMILL

CL

#3

YARD

RAILWAY LOADING TRACK



10-30'x90' KILNS

RAILWAY LOADING AND COAL TRACK

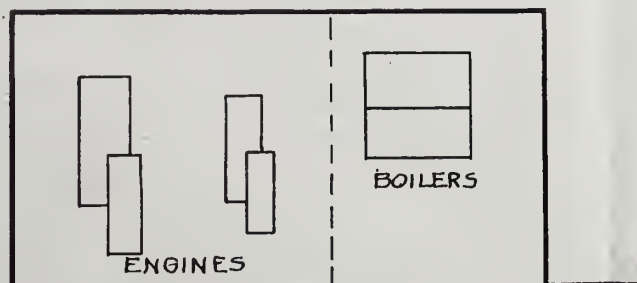
TRANSFER



FAN HOUSE

STORAGE ROOM

WASTE HEAT AND
EXHAUST HEAT DRYER

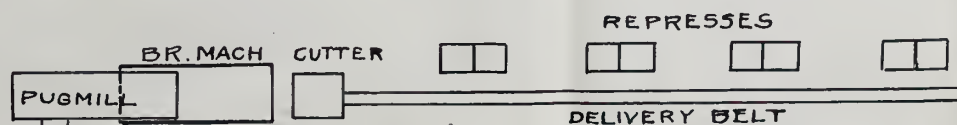


ENGINES

BOILERS

LINESHAFT

COOLING ROOM



PUGMILL

BR. MACH.

CUTTER

REPRESSES

DELIVERY BELT

CLAY TRACK

PURINGTON BRICK CO'S PLANT #3
GALESBURG ILL.
FIG. 154

Chambers brick machines running continuously for 10 hours every day making brick so fast that it is impossible to count them as they are cut. The shale is taken from a 22 foot bank and is of a very hard and dense nature. Above the shale lies 18 feet of surface clay which is rather sandy. The top clay is thrown down over the shale bank by a 90 ton Marion steam shovel, and is loaded into side dump cars by a 110 ton shovel of the same make, with the shale. A fair mixing is therefore effected in the pit. These shovels furnish sufficient clay for 360,000 brick per day at three of the four plants. The fourth which is located about 1/2 mile from the others is furnished clay by its own 70 ton steam shovel. At the first three plants a 15 ton dinkey locomotive hauls cars to the foot of a short tramway, and is used to spot the cars approximately for the shovel. The cars are pulled up the incline one at a time by the familiar hoisting drum. The locomotive hauls cars in one direction past the shovel to plant number 1, which is doubly equipped, and in the opposite direction to plant number 2 where a part of the shale delivered to this plant is ground, and sent to plant number 3 ready to be pugged. By keeping the cars going in each direction past the shovel there is no time lost in spotting cars, and the shovel is worked to its capacity thereby bringing the cost of winning the shale down to close to 1 cent a ton delivered in the dry-pan room. Since the same equipment with the same arrangement is used in all the plants it will not be necessary to describe more than one plant.

The clay is dumped into tapering shoots which lead to the dry-pans located along the dumping track. These shoots hold a car apace of the shale and are kept partially full all the time so that the maximum capacity of the dry-pans may be attained. The pans are of Frost manufacture and are 9 feet in diameter. The clay is elevated by a long smooth belt conveyor set at an angle of 25° from the horizontal and running at 700 feet per minute. The clay is delivered to 15 foot Dunlap screens. The pugging is done by 12 foot pugmills of the American Co's. manufacture, which are run at a speed much higher than the ordinary. The moulding is done as said before by Chambers 90000 capacity brick machine which runs the brick out so that they are end out instead of side cut as in the most common method. This method has the advantage of requiring a smaller amount of pressing to make a smooth and impervious brick because of the large amount of the surface of the brick covered by a skin from the die. The cutting is done by an automatic cutter of the Chambers Bros. manufacture. A long delivery belt carries the brick out to the double represses of the Eagle type. For each machine a waste heat dryer of 18 tracks with 15 car capacity is used. Each track is in its tunnel in these dryers. The heat is drawn through underground ducts from the bottoms of the stacks of the colling kilns. The kilns are of the rectangular down draft type with grateless furnaces. The furnaces are about 3 feet wide by 4 feet deep by 3 1/2 feet from front to bag wall. The fuel is thrown in the top, and is

stoked through an opening near the bottom. Some air is admitted at the fire door for combustion, and some at the stoker hole. The coal used clinkers badly due to high sulphur content, and after many trials with all kinds of furnaces this one was adopted. The Morgan Gas Producer Co. attempted to gasify the fuel in an up draft producer of their manufacture located at the end of the kiln. The attempt was an utter failure due to clinkering of the ashes in the producer although the company's engineers superintended the erection, and trial of the producers. The bag walls of these furnaces are flush with the side wall. The furnace flue is built in the side wall so that a maximum amount of brick may be placed in the kiln with the minimum amount of labor. The flue system consists of a single central flue, which is divided between three stacks, which draw from it. One stack is located at each end of the kiln, and one in the middle on one side. The loading is done into cars running past each end on sunken tracks. There are in all 57 kilns used in these plants most of which are of the rectangular type 90 feet long and about 15 feet wide but a few are 30 feet round down draft kilns. The power for these plants is furnished by corliss engines of from 350 to 450 H. P. The steam is furnished by Frost fire tube boilers in all cases except one where B. & W. water tube boilers are used. Jones underfeed stokers are used in part of the plants.

Underwood Pressed Brick Co. Springfield Illinois.

The clay used in this plant is of a chalky nature

of a yellow color, and has quite a large content of fine sand. The clay is plowed in the pit, and sun dried. It is then gathered by clay gatherers, and stored in a large shed for ageing. The clay is then run through a Stedman bar disintegrator, and mixed in a 48 inch circular mixing pan of the same make, after which it is pressed in a four mould dry-press of a very old make. The brick are run directly from the press into the rectangular down draft kilns, which are 3 in number. These kilns are about 60 feet long by 18 feet wide and have horizontal grate bar furnaces and 5 feet bag walls. The flue system is the one central main flue with open floor brickwork above it, and the remainder of the floor solid. A single 30 foot stack with 4 feet by 4 feet flue furnishes draft to the kiln. Shading is done as the brick are taken from the kiln. This factory shades its product into eight piles. The power is furnished by a 35 H. P. shunt motor using 220 volts from the city circuit. According to the current used 46100 foot pounds of work is required to make a dry-press brick at this plant.

Springfield Paving Brick Co. Springfield, Illinois.

The shale for this plant is obtained from a 28 foot bank, and is very dense in structure, and blue in color. It is excavated by blasting, and loaded by hand into tramway cars. By means of the usual winding drum the cars are pulled to the dry-pan room and dumped. There are 4-9 foot dry-pans used. After crushing the elevator delivers the clay to a perforated metal screen set at an angle of about 45° . The pugging is done

in a 12 foot Chambers pugmill, and the moulding by a Chambers 90000 capacity brick machine. An indenter is used in connection with a Chambers automatic cutter, and since the indenter rounds the corners of the brick, and the clay naturally makes into a very dense brick they are not repressed. A 20 track waste heat and exhaust steam dryer is used. The burning is done in 10 rectangular kilns 60 feet in length and 18 feet in width. The power for this plant is furnished by a 400 H. P. Joliet Corliss using steam from 4-100 H. P. fire tube boilers.

Terra Haute Paving Brick and Block Co., Terra Haute, Ind.

The shale at this company's plant stands in a 22 foot bank with nothing but a few inches of black dirt over it and 3 feet of coal directly beneath it. The shale is handled by cable from blastings and is ground in 2-9 foot brick frame dry-pans. It is screened by a 5 foot Bonnot piano wire screen after which a 10 foot Raymond pugmill is used in the process of reduction. A Raymond 90000 capacity brick machine is used for moulding. The clay is cut by a Raymond automatic two stage cutting table. The brick are pressed in 4 Bonnot double presses. The drying is done in an 18 track 15 car per track waste heat tunnel dryer, and the burning is done in 20-28 foot round down draft kilns with slanting grates and 5 foot wag walls. The floor to these kilns is of the multiple flue system with solid floor. The rise of the crowns is 5 feet and there is one stack to each kiln. The power is furnished by a 350 Bates corliss engine using steam from 4-100 H. P. Atlas fire tube boilers.

National Pipe and Tile Co. Terra Haute, Indiana.

This factory makes large tile up to 36 inches in diameter from a shale similar in nature to that used in the previous plant. A 9 foot Frost dry-pan and wet pan of similar construction is used in connection with a perforated metal screen to reduce the clay to a plastic condition. The moulding is done in a vertical sewer pipe press located on the second floor of the three story slotted floor dryer using exhaust steam in coils under the floor for heating. A system of single car gravity elevators are used to transfer the wares loaded on trucks from the upper floors to the ground. The burning is done in 14-28 foot round down draft kilns similar in construction to those used in the previous factory above described. The power is furnished by a 150 H. P. Atlas engine using steam from 3-60 H. P. Atlas fire tube boilers.

Clinton Paving Brick Co. Clinton, Indiana.

The shale for this plant is of a very tough nature and makes an exceptionally tough brick. The clay is blasted and loaded into tram-cars. The grinding is done in 2-9 foot Raymond dry-pans, and the screening in a 12 foot revolving screen 5 foot in diameter. The screen is of perforated metal, and is mounted on a wooden frame of eight sides. The pugging is done in a 10 foot Raymond mill, and the moulding in a 70000 capacity machine of the same make. A Bonnot automatic three stage rotary cutter is used with 2 Ohio Ceramic Engineering Co's. double represses. An 11 track Iron Clad Co's. dryer

using waste heat is used in drying. The burning is done in 8-16 feet by 60 feet down draft rectangular kilns with central flue and small laterals in a floor of solid construction. The openings in the floor are 3 inches by 12 inches, and placed every 3 feet in each direction. Horizontal grate bar furnaces are used with bag wall 4 1/2 feet in height. The power is furnished by a 200 H. P. Atlas Engine using the American system of rope drive to the various machines. The boilers, which are three in number are of the fire tube type and are 75 H. P. each.

Sheridan Brick Co. Brazil, Indiana.

The clay for this plant is obtained from a 25 foot bank of blue shale by a 60 ton Marion steam shovel, and is hauled to the plant by a cable tramway. The grinding is done in 3-9 foot Frost dry-pans, and the screening by course woven wire screens. The pugmill is about 14 feet in length and of unusually large capacity. The moulding which is by the soft mud process is done by the large 6 mould front delivery machines. The drying is done in an old style -24 track Iron Clad Co's. dryer using exhaust and live steam. The power is from slide valve engine using fire tube boilers for steaming purposes. The burning is done in 8-60 by 25 foot up-draft kilns fitted with the Swift patent coking table furnaces. The floor is solid as in most up-draft kilns.

Brazil Sewer Pipe Co. Brazil, Indiana.

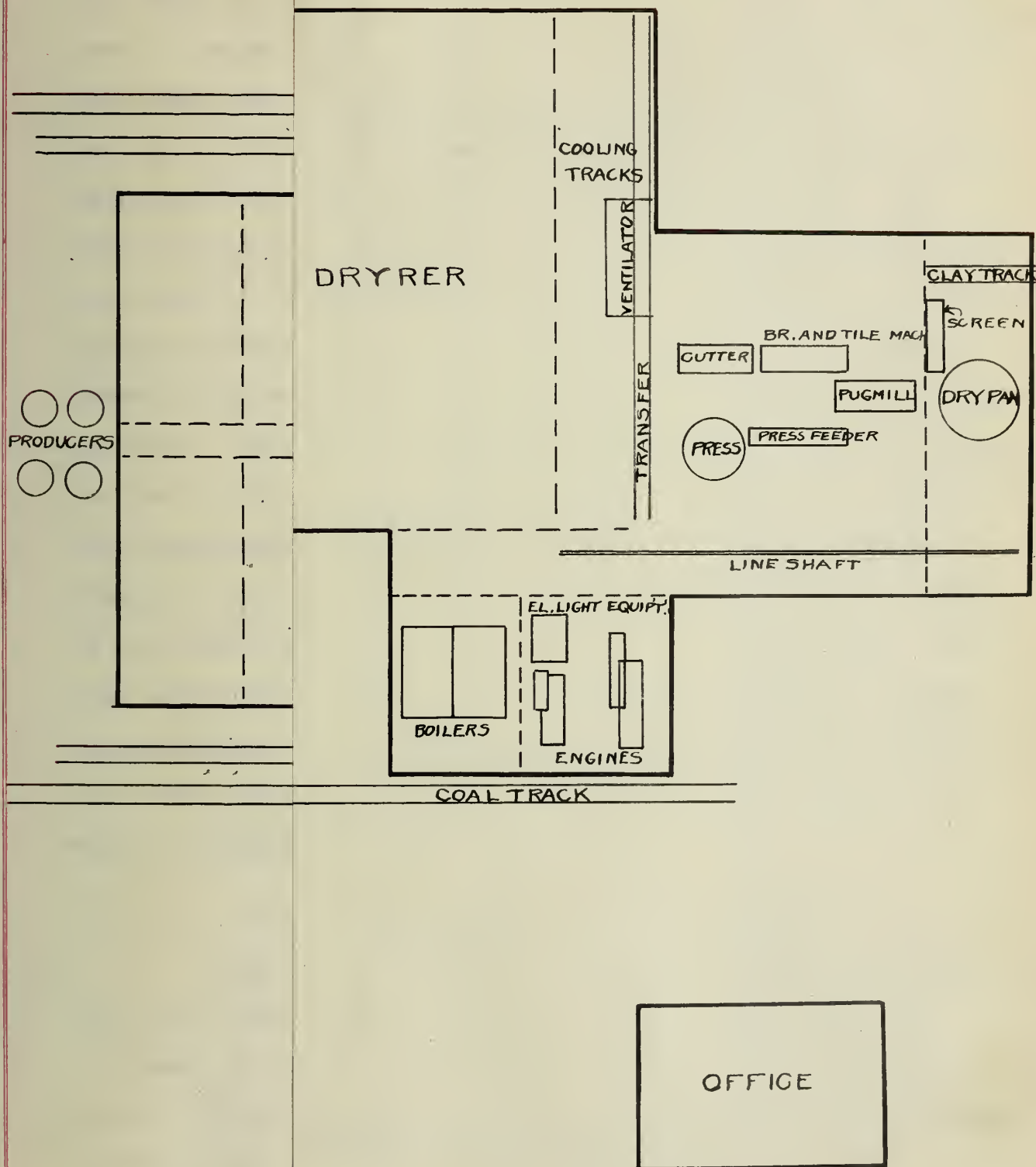
The clay for this plant is obtained from a mine 85 feet below the surface. The strata lie as follows. 1. A 3

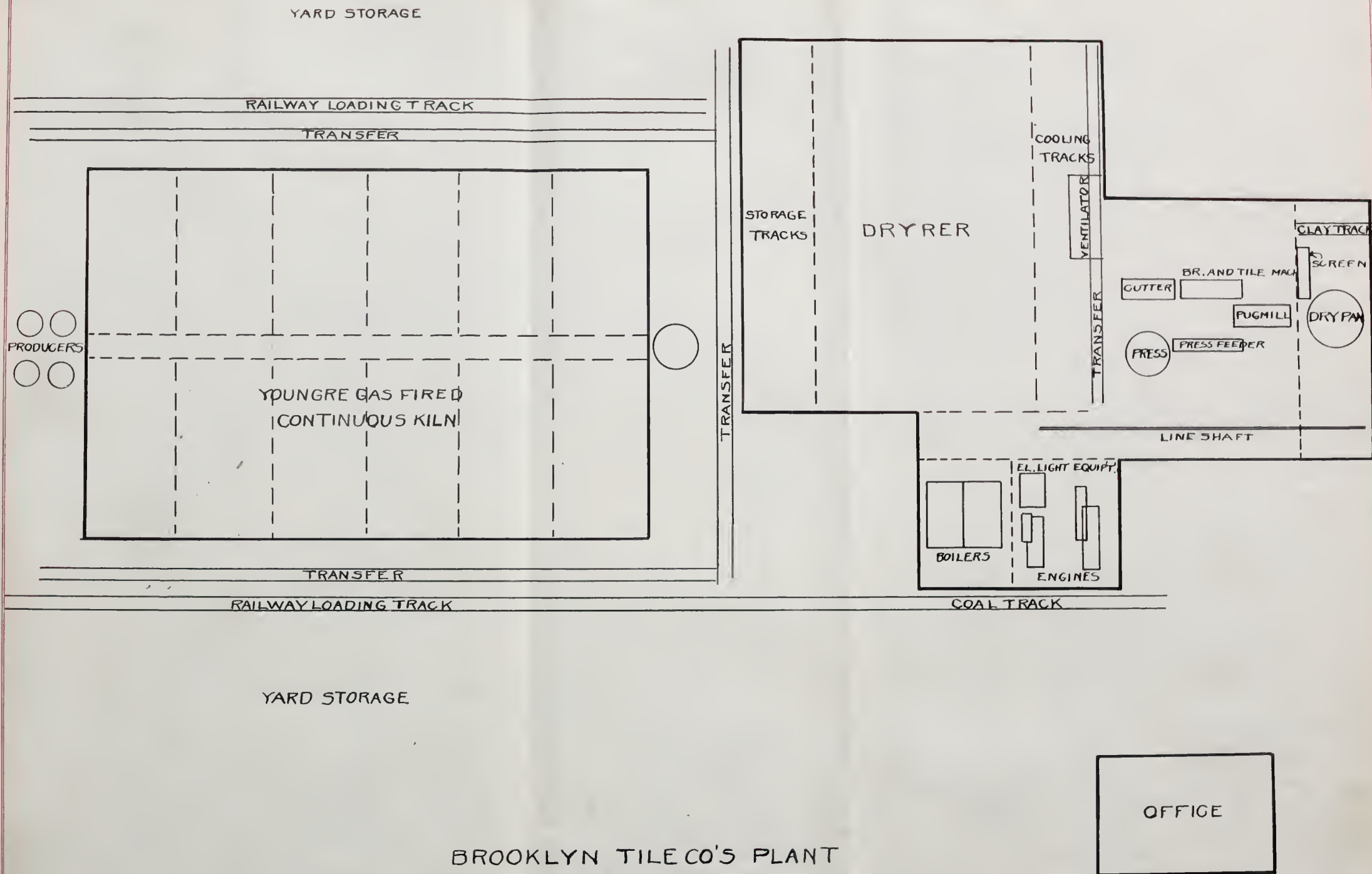
foot lead of slate under which lies, 2. a 3 foot lead of coal, 3. a four foot lead of shale. Mules and cars are used under the ground for transporting the material to the foot of the shaft while two men push the cars to the kilns, boiler room or dry-pan rooms as it is wanted above the ground. A mixture of $1/3$ slate to $2/3$ shale is ground in a 9 foot American Co's. dry-pan. The clay is screened in a 30 foot perforated metal screen with round perforations $1/8$ inch in diameter. A belt cup elevator transfers the plastic clay from the 2-9 foot wet pans to the feeder of the sewer pipe press. The dryer is three stories in height with slotted floors and exhaust steam for heating. The burning is done in 14-30 foot round down-draft kilns with slanting grates and entirely open brick work floors with the radial flue system beneath. The power is furnished by a 250 H. P. Hamilton Corliss engine using steam from 3-100 H. P. fire tube boilers.

Brooklyn Drain Tile Co. Brooklyn, Indiana.

Figure 155.

The blue shale used in this plant is obtained from a 25 foot bank by blasting, and is hand loaded into tramcars. The car used is of the low setting side dump type dumped by a revolving tippie set on trunions which turns the car almost completely over. The tippie requires no external force to work it, but is operated by the weight of clay in the car set excentrically in the tippie. A friction controller lever is used in operating. The shale is ground in a 9 foot American





BROOKLYN TILE CO'S PLANT
 BROOKLYN, IND.
 FIG. 155.

Co's. dry-pan, and run over a 5 foot Bonnot piano wire screen. A Bonnot 10 foot pugmill running at a very high speed does fine work in reducing the clay to a plastic state. The clay may be turned from this pugmill into either a Fate tile machine or a sewer pipe press. Tile up to 10 inches are made on the horizontal Fate machine using Bensing automatic cutting tables. Those above 10 inches are made in a sewer pipe press. The limit of the press is 36 inches. Cars of special construction are used for the drying of the ware. The movement of the cars is perpendicular to the long side of the car. This special construction was made necessary by the arrangement of the dryer and kiln. Heat from the continuous kiln and the exhaust steam is used in drying. The dryer is of the Standard Co's. patent and construction. The burning is done in a 14 foot Chamber Youngren continuous kiln using producer gas as a fuel. Power is furnished by a 200 H. P. Corliss engine of Bates Mfg. Co., make using steam from 2-100 H. P. fire tube boilers. A high speed engine, and directly connected General Electric dynamo furnishes current sufficient for 50 lamps. This plant is a model of neatness and good design.

Illinois Brick Co. Chicago, Illinois.

The clay for this plant is obtained from a 30 foot bank of a very uniform nature. The clay is of a fine grain and sandy in nature, and very easily reduced to the plastic state. It was no doubt deposited as sediment by Lake Michigan. There is very little gravel in this material. The clay is

loaded upon 2 yard side dump cars by a 45 ton Marion steam shovel with a 1 1/2 yard dipper. A train of four cars drawn by a dinky locomotive is delivered at the foot of a tramway. The cars are dumped one at a time into a granulator which feeds a constant quantity of clay to a pair of corrugated conical rolls by means of a smooth belt conveyor set between the machines. This belt is set at 20° to the horizontal. The clay from the rolls is then taken by another belt conveyor of similar construction to the 12 foot Chambers pugmill. The blades of this pugmill are constructed so that they may be set at any angle from the plane of revolution. An exact method of regulating the speed of pugging is thus secured. The moulding is done in a large 90000 capacity Chamber's brick machine using Chamber's automatic cutter. This machine is capable of running 500 brick per minute. The brick are run out on a delivery belt about 150 feet in length. The delivery belt runs directly past the dryer transfer and thereby obviates a long transfer of cars. Another advantage of this system is the many points at which the loading can be done at once. The tunnel dryer has 18 tracks which each hold 30 cars. The tracks being so long necessitates that the moisture laden air be removed before it has traveled the full length of the dryer. The draft stack is, therefore, located in the center of the dryer. The heat is from exhaust and live steam. The burning is done by an ^{old} fashion, but in this case a very effective method i. e., that of using the old clamp kiln. The brick are

piled 64 tiers high, and in piles 100 feet long by 30 feet wide. There is a loose wall laid up all around the pile, and it is plastered with a mud mortar. Holes are left at the bottom of the wall opposite the arches, built in the pile for firing. These arches are about 3 feet high and 18 inches wide. The firing is done by the use of oil burners using a crude petroleum and compressed air. The burner is placed in the arch. When the brick are burned the outside wall is torn down and the brick are loaded directly into cars for the market. The brick produced are rough but make a good backing, and are sold very cheaply. The power is furnished by a 350 H. P. Corliss engine using steam from 4-100 H. P. fire tube boilers. This company has a foundry and machine shop where all castings are made, and finished for this and several other plants owned. The other plants owned by this company are exact duplicates to this plant in respect to equipment.

Calumet Brick Co. Chicago, Illinois.

A similar clay to that used at the previous plant is handled by a 60 ton steam shovel loading into 3 yard cars. The cars are pulled by a cable 700 feet in length to the dump. The clay is treated in a similar manner to that just described in the previous plant, and is also run out on a long delivery belt. The brick are then piled 14 high two over two upon 2 inch by 12 inch by 3 feet plank palates which are carried off three at a time by a jack car (a car which runs under the palates as they stand on the loading racks, and lifts them clear and carries them to the drying rack, where they are put

down). The ground under the drying rack which support the palates is overlaid by 6 pipes carrying exhaust steam. This dryer has 92 tracks each about 80 feet long and has a capacity of about 1,500,000 brick. These brick are dried in from 2 to 3 days. The burning is done in clamp kilns of the same construction as used by the Illinois Brick Co. Power is furnished by a 350 H. P. Corliss engine using steam from hand fired B. & W. Water tube boilers.

Alsip and Hoyt Brick Co. Chicago, Illinois.

This plant has a very similar equipment in all respects to that used in the previous plant. In this plant the equipment is duplicated so as to make a plant with the output of two as in the Purington plant #3. The brick are taken from the delivery belts, and loaded upon tracks. They are placed on end on a hot floor using the exhaust steam for heat. The burning is done in clamp kilns. The power for this plant is from a 450 H. P. Erie City Iron Works's engine using steam from 6-80 H. P. fire tube boilers.

Burnham Bros. Milwaukee, Wisconsin.

In this plant a yellow clay is used in a soft mud machine. The drying is done in an open air rack system 3 palates deep on the racks. There are 6 brick to the palate in this plant. The brick are burned in a Youngren gas fired continuous kiln built after the first design. This design as explained in the chapter on burning has small producers for each

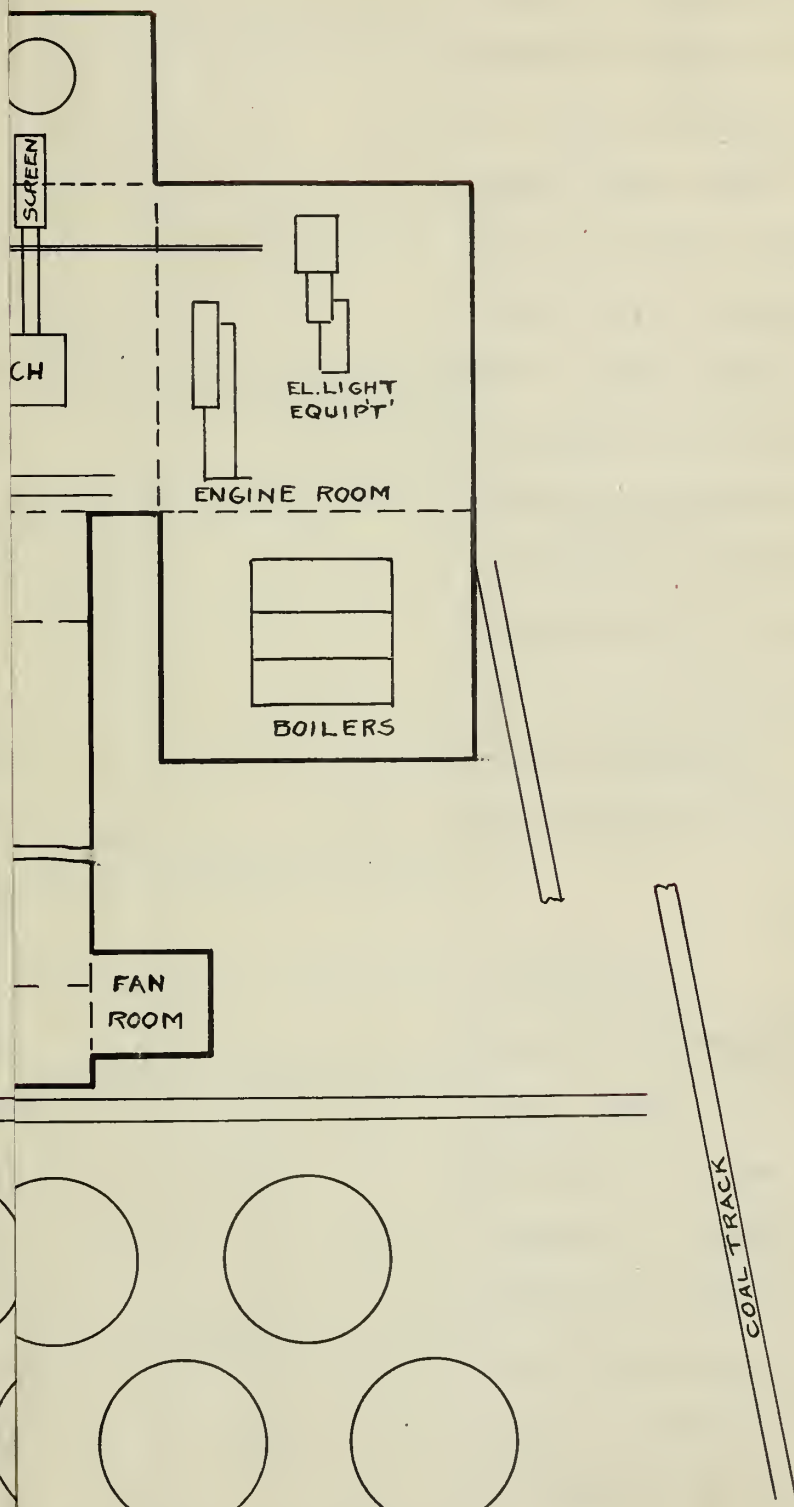
chamber instead of the continuously operated producer at the end of the kiln as is used in the latest design. This company owns and operates several plants in and around Milwaukee all using the soft mud process. Most of these plants use Youngren continuous kilns.

Barber Asphalt Co. Des Moines Iowa.

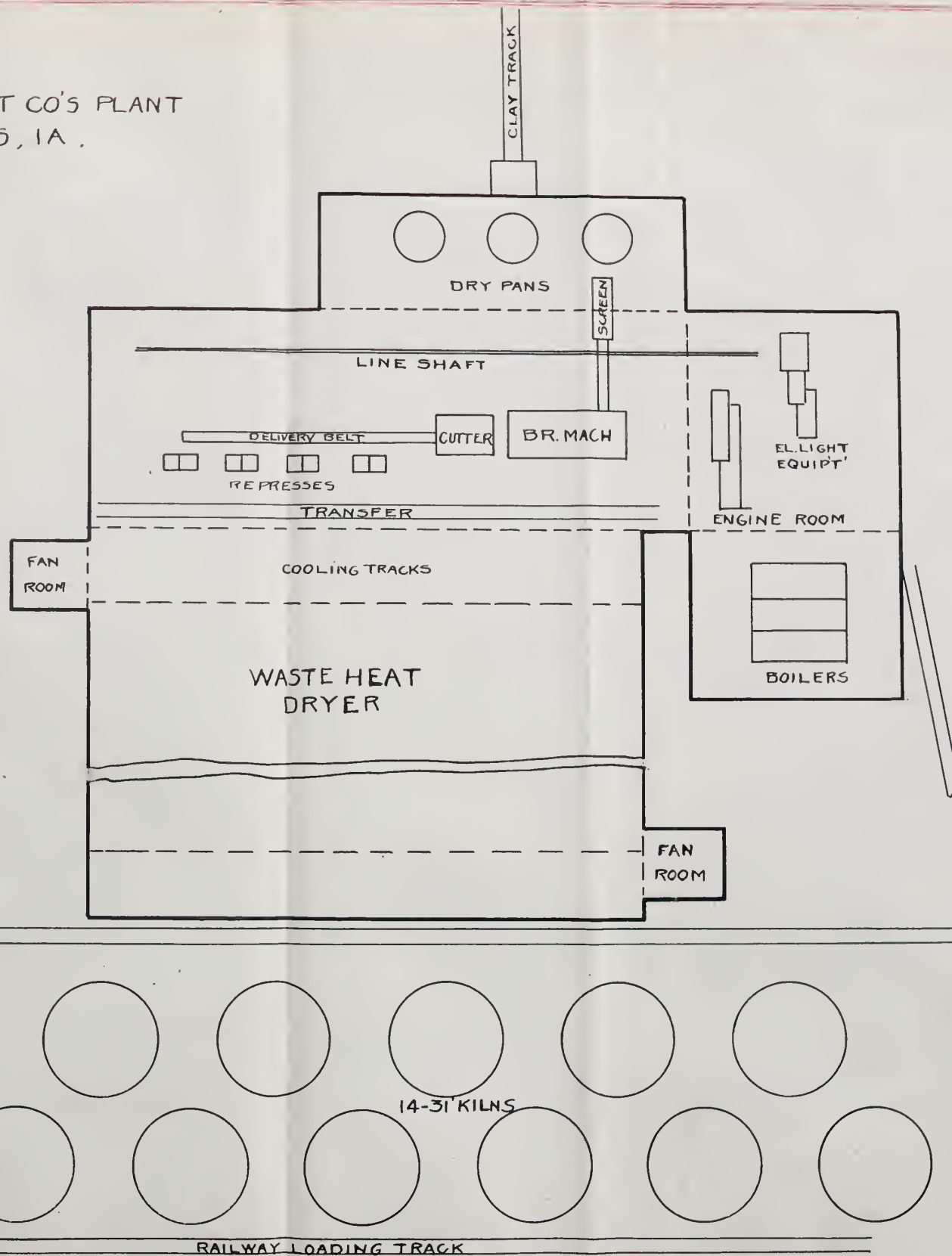
Figure 156.

The shale used in this plant is taken from a bank with a depth of 90 feet of excellent material. The shale is at present blasted, and taken to a 2 foot continuous bucket Caldwell elevator, which is set slightly slanting. The clay is elevated to a level a little above the 3-9 foot Eagle dry-pans. The clay ground by these is screened by 2-8 1/2 foot Bonnot piano wire screens. The pugging is done in a 17 foot mill, and moulded in a Bonnot machine of the Admiral Dewey type. The brick are cut by an automatic cutter, and pressed by double represses, both machines of which are of the Bonnot Co. manufacture. The brick are dried in a tunnel dryer on steel deck cars. The tunnels contain but one track each. The partition walls between tracks are built of hollow blocks and the roof is of reinforced concrete. The heat for drying is furnished by the cooling kilns, or, when there are no kilns cooling, by a furnace. The heat is drawn from the kilns by goose necks in the doors connected to underground tunnels. The fan forcing the heat into the dryer is 13 feet in diameter, and runs at about 170 R. P. M. Another fan, slightly smaller,

BARBER ASPHAL
DES MOINE
FIG. 156



BARBER ASPHALT CO'S PLANT
DES MOINES, IA.
FIG. 156



is used to pull the moisture laden air from the dryer. The burning is done in 14-31 foot round down-draft kilns. The horizontal grate furnace is used with flash walls 5 feet in height. The flue system consists of a series of parallel flues 8 inches apart. These flues are covered by ordinary floor brick, and make an entirely open brick floor. The small flues lead into a main central stack flue running diametrically across the kiln. A very even draft is secured from this floor system. Stacks 60 feet in height each furnished draft to four kilns. The power is furnished by a 300 H. P. Corliss engine for the main line shaft, and an Erie City engine is directly connected to a 60 K. W. dynamo, which furnishes light. Rodgers throttling engines furnish power for the fans. The steam to all is supplied by 3 fire tube boilers. All buildings are of brick, concrete, and steel construction, and are, thereby, made fireproof. A simple protection is therefore secured from the many fires around the average brick yard.

Alton Paving Brick Co. Alton, Illinois.

The shale employed by this company in the manufacture of a paving brick is light in color, and very tough. It lies very uniformly in the bank. The 1 1/2 yard cars are loaded by a 55 ton Marion steam shovel which is capable of excavating in 10 hours sufficient shale for 40000 standard paving brick. The shale is reduced in 2-9 foot Fay Sheckler dry-pans, and screened by a piano wire screen. The pugging is done in an American mill, and an American Co's. brick machine is used in

the moulding. The cutting is done by a rotary cutter, and the pressing by 3 double Eagle represses all made by the American Co. The drying is done in a 16 track Iron Clad Co's. dryer. There are at present being added to each side of the old dryer 3 tracks to be heated by the J. D. Cummer & Co's. method of direct heat, as explained in the chapter on dryers. A dry press face brick is also made at this plant from a yellow clay overlying the shale. This clay is loaded into side dump cars by a 25 ton Threw steam shovel, and dumped directly into a Bonnot rotary direct heat dryer. The dried clay is ground, and stored in a V shaped hopper bin for use as needed by the Fernholtz 6 mould dry press. All the products of this plant are burned in 6-60 feet by 14 feet rectangular down-draft kilns with single flue in floor leading into multiple stacks in the walls, and by 1-16 chamber Youngren gas fired continuous kiln. This Youngren kiln is of the latest design. The chambers are 18 feet by 30 feet. The draft is mainly induced by a large power fan throwing its gases into a short stack. A high stack was formally used but due to insufficient draft, and the sulphuric acid in the gases passing out it had to be fallen. The sulphuric acid had so eaten the cement mortar away that parts of the top had already fallen away at the time of the writers visit. The power is furnished by a 250 H. P. Corliss engine and 2-150 H. P. fire tube boilers.

Christy Fire Clay Co. St Louis, Mo.

The fire clay used in this plant is obtained from a

mine $3/4$ of a mile from the plant location. The lead varies from 6 feet to 10 feet, and is mined easily without blasting. The loaded 2 yard side dump cars are pushed to the plant by a 15 ton dinkey locomotive. The clay is then ground in dry-pans, and after wetting it is placed in a large clay cellar for aging to increase the plasticity. The process of aging requires from 3 to 6 weeks. The moulding is done in dry presses horizontal brick machines with a Eagle double repress, and in hand presses. The ware dried in direct heat dryers, where drying is necessary. The kilns of this plant are of 4 general types. 1. The Hoffman 16 chamber continuous tunnel kiln is used for the ordinary fire brick. It is fired with a very good grade of Pennsylvania coal, which costs \$3.50 per ton delivered yet a saving is realized in burning over the cost of burning by ordinary down-draft kilns. 2. There are 25-25 foot to 30 foot round down draft kilns of the common construction of horizontal furnaces and multiple duct flue system. These kilns have in place of the usual bands at distances of about 1 foot apart as found on most round kilns a single $3\frac{1}{2}$ inch band, which holds the kiln in shape, and the crown in its position. 3. An 18 chamber gas fired continuous kiln is also used. This kiln was designed, and constructed by the company's engineering staff, and is a most economical kiln. It does not differ from the Youngren kiln of the latest design in general principle. The two rows of chambers are separated about 30 feet thus allowing a passage way down through the center to facilitate empty-

ing and filling. All the flues are underground. The chamber floors are 15 feet by 18 feet. Their height is 12 feet. The bracing is done by steel rods in place of slanting brick walls of heavy construction. 4. Part of the clay is calcined for the most refractory of wares in upright calcine kilns, built much the same as a plast furnace. The power is furnished by 2-300 H. P. and 1-100 H. P. Corliss engines directly connected to 220 volt electrical generators. The power is furnished to the machines by direct current motors with belt drives. The boiler plant consists of 8-100 H. P. O'Brien water tube boilers with Roney stokers using washed pea coal.

Parker Russel Mining and Mfg. Co. St Louis, Mo.

The clay used by this company is the same as used by the Christy Co. and is ground, and aged in the same manner. Here large gas retorts are made as a speciality. The retorts are about 12 feet in length with an area of cross-section of about 4 square feet. The thickness of the wall of the retort is about 2 inches. These are dried upon a hot floor which may be regulated very accurately. The drying of these large retorts is a very delicate operation and requires from 15 to 20 days for this part of the manufacture alone. Several hand presses are also used for the making of a high grade of fire brick. These hand made brick are dried on 2 slatted floors of 50000 capacity each. The retorts and brick are burned in rectangular down draft kilns. A battery of these kilns is fired by gas from a central gas producer system. Power is furnished

by 3-100 H. P. O'Brien water tube boilers and corliss engine.

Progress Press Brick and Machine Co. and

Enterprise Brick Co.

St Louis, Mo.

These companies are using a yellow top clay of a probable loess deposit in a dry press process. Two types of presses are used by these companies. 1. The old hammer type striking the brick several blows. 2. The pressure type which presses and does not do any of its work by impact. The burning is done in up-draft scove kilns using coal on horizontal grates. The product produced is several shades of red.

Blackburn-Post Pipe Co. St Louis. Mo.

This company which is the oldest in St Louis dates its incorporation from 1852. The clay used at this plant is shipped from Glencoe a distance of 25 miles out of St. Louis. The clay is part fire clay and part shale. The grinding is done in a battery of dry and wet pans all operated from one common pinion shaft. The pressing is done in large sewer pipe presses which have dies sufficiently large to press a 48 inch pipe. The pipes are burned in 30 foot round down-draft kilns. The open floor is used in connection with horizontal grate bar furnaces.

Evans and Howard Fire Brick Co. St Louis, Mo.

This plant, which is a very large one, makes all shapes of fire brick and all sizes of sewer pipe in a similar manner employed in the previous plant.

Laclede Fire Brick Co. St Louis, Mo.

This company has a vast jungle of kilns and plants erected without any intent toward system since 1858. Their output consists of dry pressed brick, fire brick, special shapes of face brick and all special shapes of fire clay products. This company also makes a high grade of clacined fire brick, which contain about 10% of bauxite which is shipped from Arkansas deposits. The kilns used are mostly of the round down-draft type, but a few of rectangular form are used. The clay used is partly mined at the plant, and partly shipped in from Glencoe.

Hydraulic Pressed Brick Co. St Louis, Mo.

This company has several plants in the outskirts of St Louis, which use a mixture of fire clay and shale for making dry pressed face brick. The dry press used by this company is a patent of their own, and is used almost exclusively by them. The pressure on the brick is applied through a piston upon which a pressure of 2750 pounds to the square inch is exerted. The pressure brought to bear upon each brick is about 150,000 pounds. This enormous pressure, when brought to bear upon the dry dust makes a brick which has a stiff mud appearance although the water present in the dust is probably less than 4%. The burning is done in rectangular down-draft kilns using Swift coking tables. The power is supplied by Corliss engines using steam from fire tube boilers. Over 2000 men are employed in all the plants.

Straight Bros. Co. Fonda, Iowa.

The clay for this plant is of a glacial deposit being yellow on top, and very dense blue nature from 20 feet below the surface on downward. The clay is plowed, and dried in the pit. It is then bunched, and gathered by clay gatherers. The cars are of 1 1/2 yard capacity and bottom dump. The clay is crushed in a 9 foot Eagle dry-pan, and screened by 10 foot piano wire screens of the company's own construction. The pugging is done in a 12 foot Fate mill and the moulding in a Fate combined pugger, and brick and tile machine. Beusing automatic cutters are used, with a belt delivery to off-bearers with trucks, for the small tile. Tile from 8 inches to 16 inches are cut on a hand cutting table. Slotted floors with shelf elevators for the ware to be dried on upper floors are used. The exhaust steam is used in 1 inch pipes under the first and second floor of the three floor dryers. The drying floors cover approximately 80000 square feet of surface. The ware is taken from the sheds in barrows which are transfered from the floor to the ground by gravity elevators. The 6-30 foot round down-draft kilns used in burning have horizontal fire boxes with 6 inch flash walls and a radial flue floor system leading to a central draft well. The draft well is connected to the 30 foot -3 foot by 3 foot stack by a large under ground flue. The power is furnished by a 125 H. P. Atlas 4 valve engine using steam from a 150 H. P. fire tube boiler.

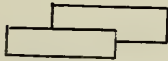
Straight Bros. Co. Spencer, Iowa.

Figure 157.

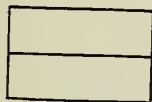
The clay for this plant is obtained from a pit of a probable sedementary origin. The clay exists in several strata of different formation. The first 8 feet after the black dirt stripping is removed is of a very tough nature with considerable iron coloring. Under this comes 2 feet of a very plastic and tough clay with no gravel in it at all. The remainder of the clay above a bed of gravel, which lies about 30 feet below the surface is of a very lean (non-plastic) nature and is a rather hard drying clay. The clay is gathered by plowing, and using wheel scrapers dumping into a tramcar bridge. The storage bin into which the cars are dumped holds sufficient clay for a one week run. The clay from this bin is elevated by a belt conveyor to a bar roller disintegrator in which it is cut ot pieces so as to be more easily pugged. The pugmill 8 feet in length is used in connection with the pugmill of the Fate combined brick and tile machine. The cutting is done by Bensing automatic cutters for the small tile and a hand cutting table for tile above 10 inches. The drying is done in a four storied building 60 feet wide with slotted floors. The exhaust steam is piped under the first and second floors, and is usedin connection with the natural drying from the large doors on all sides of the dryer. The 8 kilns used are 30 feet in diameter and are of the same construction as those used at Fonda. The power is furnished by an Erie City engine using

SUPPLIES

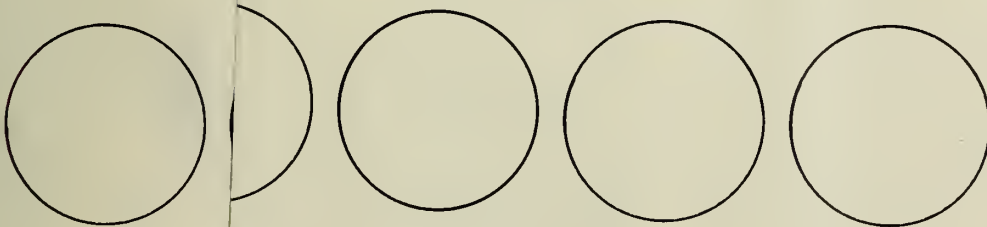
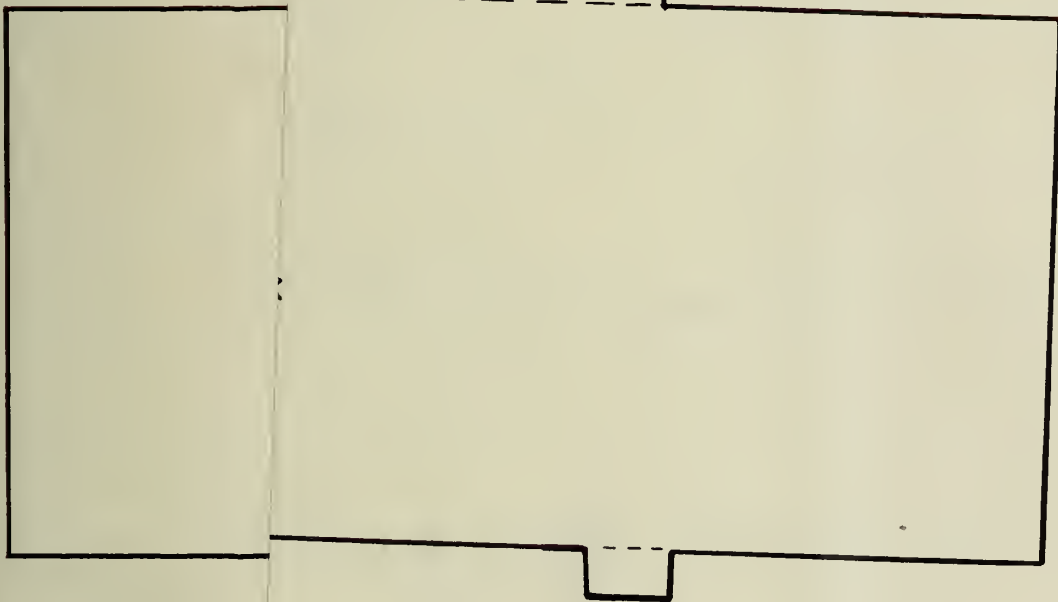
LINE SHAFT.



ENGINE



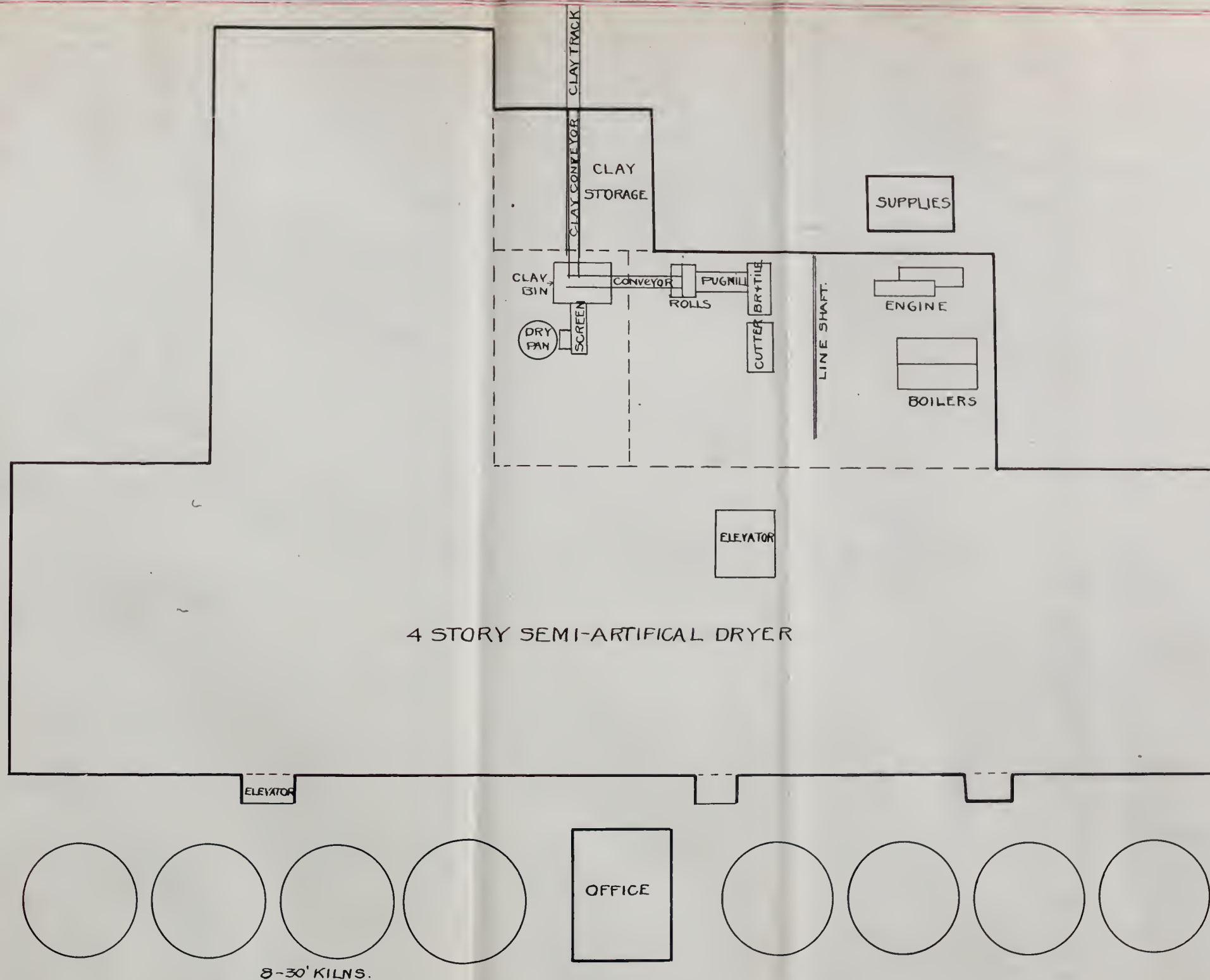
BOILERS



CER IA.

YARD STORAGE

COAL TRACK



RAILWAY LOADING TRACK

STRAIGHT BROS. CO'S PLANT SPENCER IA.

FIG. 157

COAL TRACK

YARD STORAGE

steam from a fire tube boiler.

Stipes Brick Co. and Barr Brick Co. Urbana, Illinois.

These companies use a yellow glacial clay in the manufacture of a soft mud brick. The clay is run through granulators and smooth cylindrical rolls into the pugmill of the soft mud machines. The drying is done in open air racks on palates. The burning is done in scove kilns with horizontal grate bar furnaces.

ITINERARY OF FACTORY VISITS.

1. Barber Asphalt paving brick plant,
Des Moines Iowa. Spetember 6, 1906.
2. Burnham Bros Brick Co.
Milwaukee Wis. November 17, 1906.
3. Wabash Clay Co.
Veedersburg Indiana, November 22, 1906.
4. Veedersburg Clay Co.
Veedersburg Indiana. November 22, 1906.
5. Postum Brick Co.
Crawfordsville, Indiana. November 22, 1906.
6. Stipes and Barr Brick Cos.
Urbana, Illinois. December 15, 1906.
7. Western Brick Co.
Danville, Illinois. December 17, 1906.
8. Streator Paving Brick Co.
Streator Illinois. December 22, 1906.
9. Barr Clay Co.
Streator Illinois. December 22, 1906.
10. American Brick and Tile Co.
Mason City Iowa. December 31, 1906.
11. Mason City Sewer Pipe Co.
Mason City Iowa. December 13, 1906.
12. Mason City Clay Co.
Mason City Iowa. Jan. 1, 1907.
13. Mason City Brick and Tile Co.

Mason City Iowa. Jan. 1, 1907.

14. The Purington Brick Co's. plants,
Galesburg, Illinois. Jan 2 and 3, 1907.
15. Underwood Pressed Brick Co.
Springfield, Illinois. Jan. 3, 1907.
16. Springfield Paving Brick Co.
Springfield Illinois. Jan. 3, 1907.
17. Terra Haute Paving Brick and Block Co.
Terra Haute Indiana. Jan. 4, 1907.
18. National Drain Tile Co.
Terra Haute Indiana. Jan. 4, 1907.
19. Clinton Paving Brick co.
Clinton Indiana. Jan. 4, 1907.
20. Sheridan Brick Co.
Brazil Indiana. Jan. 5, 1907.
21. Brazil Sewer Pipe Co.
Brazil, Indiana. Jan. 5, 1907.
22. Brooklyn Tile Co.
Brooklyn Indiana. Jan. 5, 1907.
23. Mc Cleed Brick Co.
Indianapolis Indiana. Jan. 6, 1907.
24. Alton Paving Brick Co.
Alton Illinois. Feb. 3, 1907.
25. Laclede Fire Brick Co.
St Louis, Mo. Feb. 4, 1907.
26. Parker Russel Mining and Mfg. Co.
St Louis, Mo. Feb. 4, 1907.

27. Winkle Terra Cotta Co.

St Louis Mo. Feb. 4, 1907.

28. Blackburn Post Pipe Co.

St Louis, Mo. Feb. 4, 1907.

29. Progress Brick Co.

St Louis Mo. Feb. 5, 1907.

30. Enterprise Brick Co.

St Louis Mo. Feb. 5, 1907.

31. Evans and Howard Fire Brick Co.

St Louis Mo. Feb. 5, 1907.

32. Christy Fire Clay Co.

St Louis Mo. Feb. 5, 1907.

33. Hydraulic Brick Co.

St Louis Mo. Feb. 5, 1907.

34. Illinois Brick Co.

Chicago, Illinois. March 1, 1907.

35. Calumet Brick Co.

Chicago Illinois. March 1, 1907.

36. Alsip and Hoyt Brick Co.

Chicago Illinois. March 1, 1907.

37. Straight Bros. Co.

Fonda Iowa.

38. Straight Bros. Co.

Spencer Iowa.

39. Hylard and Johnson.

Spencer Iowa.

GLOSSARY OF TERMS AND WORDS NOT IN COMMON USE
OUTSIDE OF THE CLAYWORKING INDUSTRY.

a,b,-

blunger; (n) a machine to reduce clay to a liquid consistancy.

bisquett; (v) To burn fine ware before adding glase.

burn; (n) used to designate one emptying and filling of the kiln sometime called a heat.

bone dry (adj) the state in which a clay is air dry.

c,-

check; (v) The cracking of a clay in drying, water-smoking or cooling. Only small cracks called checks.

d,e,f,-

flash; (v) The action of the flames upon the surface of some clays producing a golden brown.

form; (n) a guide by which arches and crowns are built.

g,-

gauge; (n) A guide by which crowns and other brick works are built. Used as a verb to gauge a crown.

goose-neck; (n) a right angle connection used to make connection between the underground flue and door for using waste heat.

green; (adj) The state of a ware as it comes from the machine and as long as it is not apparently air dried. To set green is to set ware in the kiln with apparent mechanical

water.

h,-

hack; (n) A pile of brick or tile set one upon the other. To hack up a pile when used as verb is to pile one piece upon another.

header; (n) A brick course laid in the wall with ends outward.

heat; (n) A burn.

l,-

lead; (n) A strata of clay or coal.

m,-

mount; (v) Used in connection with the mullers of a dry-pan when the large chunks are so hard that they cause the mullers to ride over them without being crushed.

o,-

off-bear; (v) To take ware away from a machine as it is being made. (n) A man who takes ware from a machine.

p,-

plunger; (n) A ram.

pugger; (n) A paddle on the maxing shaft or the center shaft of a pugmill or moulding machine.

q,r,-

run dry; (phrase) Used in connection with a dry pan when the clay is all allowed to run out and only gravel too large to pass through the screen plates remain.

s,-

Steam; (v) The act of adding moisture to clay used in dry-press processes by submitting the clay to steam pressure.

set; (v) To hack, to form a pile, to arrange the ware in the kiln.

shade; (v) To arrange high grade face brick into piles all of the same degree of color.

skewback; (n) A special shape of brick used in arches and a few other constructions where a bearing is made by cutting away the corner of a block and setting it in the vertical wall. Courses laid at acute angles with the horizontal.

skin; (n) The smooth polished surface made by the die on a moulding machine.

slum; (n) A liquid clay.

slummer; (n) A machine used for reducing the clay to a liquid consistency.

strike; (v) To smooth off the surface by a straight edge.

streacher (n) A course of brick laid with sides of brick on outside of wall.

t,-

tailings; (n) Course clay and gravel too large to pass through screen sometimes called screenings.

truck; (n) A barrow used by off-bearers and filmmen.
(v) To off-bear ware away from a machine, to carry ware away on barrows.

w,-

win; (v) To excavate and place in a shed or other storage clay for future use.

v,-

vein ; (n) A strata of clay or coal.

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